



LIFE SCIENCES & MISSOURI'S ECONOMIC FUTURE:

AN OPPORTUNITY TO BUILD “ONE MISSOURI”

PREPARED FOR:

The State of Missouri

The University of Missouri System

The Danforth Foundation

The Ewing Marion Kauffman Foundation

PREPARED BY:

Technology Partnership Practice

Battelle Memorial Institute

Cleveland, Ohio

January 2003



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Final Report

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PREFACE

“**One Missouri**” represents an opportunity for the State of Missouri, in partnership with industry, philanthropic sources, and others, to engage in a multiyear effort to position the state as a major Midwest Center in the life sciences, with world-class research stature translated into wealth creation and well-paying jobs for the state’s current and future generations. But, Missouri is lagging other states, in the Midwest and elsewhere, and the current state budgetary crisis is moving the state backwards. Over the next several years, Missouri must take seriously the challenge to build its life science base, working with and building on the momentum already being generated in both Kansas City and St. Louis around their complementary life science efforts. If Missouri fails to join with private sector partners and others from these and other regions of the state, these regional efforts will not realize their full potential and others may soon eclipse both the state and its regions.

This “**One Missouri**” **Life Science Strategy** includes a series of important, interrelated programs and investments that must be thought of as an integrated whole. This strategy has identified the key gaps facing the state in becoming a major Midwest Life Science Center and identified the strategies and actions to address these gaps. *What faces Missouri today is this simple fact: Missouri is neither a clear leader nor a straggler in today’s life science world.* The state has considerable assets—such as its public and private higher education institutions, unique research organizations such as the Stowers Institute and the Danforth Plant Sciences Center—but to achieve their full potential and to address the economic well-being of the state’s citizens will require additional resources and the creation of “connective” infrastructure for research to be turned into firms and jobs in Missouri.

Missouri is at a critical “fork in the road”—does it want to rest on its traditional base in bioprocess manufacturing, slowly being eclipsed by other states and regions? Or does it want to take advantage of its existing assets and truly position itself as a leader? It is widely recognized that knowledge, innovation, and intellectual capital determine each state’s economic vitality. The life sciences represent a comparative advantage on which Missouri can build its future as a knowledge state—both in its science and technology research capacity and its talent. While the timing has never been better for all Missourians to come together under a common agenda—life sciences—it remains to be seen if the state government, in partnership with the private and nonprofit sectors, is up to the challenge of being a leader.

The life science sector is about cutting-edge, world-class research; building the facilities in which to conduct research; equipping the labs; and attracting star faculty. But, it is more than that—it is also about linking industry with academe to undertake and solve industry needs and problems that result in new products and disease treatment and prevention.

Missouri today is not known as a life science state. But, this examination of Missouri has identified many assets and resources around which a fairly strong industry base has emerged over many decades. Excluding hospitals, Missouri’s life science industry base is within 5 percent of the national average in concentration. However, it is dominated by mature industries such as those in food and nutrition and organic and agricultural chemicals subsectors. During the past decade, the state’s strengths in drugs and pharmaceuticals and medical devices and instruments

have declined steadily. Indeed, Missouri is not a growth state or a dynamic leader in two of the key drivers of the biorevolution—research and testing and drugs and pharmaceuticals.

Extrapolating current trends in Missouri’s life science industry base over the next decade is projected to result in a loss of over 9,000 jobs in drugs and pharmaceuticals and nearly 1,800 jobs in medical devices and instruments, along with very slow growth in the mainstays of Missouri’s economy—food and nutrition and organic and agricultural chemicals—which together are projected to expand by just over 400 jobs. By 2012, drugs and pharmaceuticals in Missouri would shrink to just under 5,400 employees—a 50 percent decline from today—and medical devices employment would shrink 14 percent. Whereas Missouri is 95 percent as concentrated in the drug and pharmaceutical industry today, by the year 2012 under current trends it would be 26 percent as concentrated; similarly, for medical devices, it would move from 76 percent as concentrated to 52 percent. **In short, Missouri, if current trends continue, will be eclipsed as a life science-driven economy by other states and regions.**

Battelle forecasts that, if the state aggressively pursues the life sciences and makes the necessary investments over the next 10 years in the research capacity and technology commercialization areas specified in this report, the state would add more than 21,000 permanent jobs in life science industries, for the most part well-paid, quality employment. Drugs and pharmaceuticals, research and testing, and other parts of the state’s newer emerging industries could expand and grow, helping to diversify the life sciences from Missouri’s traditional bioprocessing manufacturing base, while protecting employment in these traditional sectors.

The life sciences represent an opportunity for Missouri to diversify its economy, moving from durable manufacturing to value-added agriculture, manufacturing, and product development. Building a strong life science industry will provide disposable income that also will enable services and other industries to grow in the state. It will mean keeping scientific and technological talent in Missouri and leveraging significant federal, industry, and other funds, many fold what the state government itself invests.

The strategy, *Life Sciences & Missouri’s Economic Future: An Opportunity to Build “One Missouri,”* is a three-prong approach to promote technology-based development in the state through increasing research capacity, aggressively implementing economic development initiatives, and striving to improve the technical aptitude of the state’s workforce. The report proposes four strategies and 20 actions. Realistically, all 20 actions cannot be taken at once. Consequently, a set of priorities identifies those actions that can begin now and others that can begin in two, three, or four years. These actions are intertwined and connected, but they are also phased in a time sequence for consideration and implementation. The state and its private and nonprofit partners will need to “ramp up” this strategy dependent on resources available. Keys to the success of strategy implementation are sufficient resources to invest and the ability to invest them on a timely basis. While recent actions of the Missouri state government are not favorable, it should be noted that the two- to three-year window for action is still open. If Missouri does not choose its “fork in the road” consciously, deliberately, and with full knowledge of the consequences, it may take a fork that neither it nor its citizenry chooses. This strategy specifies that one fork may take Missouri to 21,000 additional well-paying jobs, \$7.2 billion in additional gross regional product, and more than \$3.9 billion in real disposable income over the next decade. The other fork may not only cost the state these jobs, but, if the state and the private

sector simply continue existing trends, it may also mean further significant job and economic losses in key life science industries such as drugs and pharmaceuticals and medical devices.

Table of Contents

	Page
Preface	iii
Abbreviations and Acronyms	xi
Executive Summary	xv
Introduction	1
Missouri’s Life Science Base	5
Missouri’s Life Science Research Enterprise	5
Missouri’s Life Science Industry	9
Core Focus Areas on which to Build Missouri’s Life Science Base	15
Areas of Core Research Strength in Missouri	15
Strategic Assessment of Missouri’s Core Research Strengths	19
Development Implications of Core Research Areas	19
Key Policy Issues that Missouri Needs to Address to Leverage its Core Research Strengths	22
Assessment of Missouri’s Competitive Position	25
Key Success Factors	25
Comparing Missouri with the Benchmark States	28
Building R&D Capacity in the Life Sciences	29
Knowledge Transfer and Commercialization	35
Risk Capital	37
Technology Infrastructure	41
Incentives and Tax Policy	42
Workforce	43
Summary	45
Situational Analysis	47
Strengths	47
Weaknesses	50
Opportunities	53
Threats	54
Summary	55

Table of Contents

(Continued)

	Page
Missouri’s Life Science Strategies and Actions.....	57
Vision and Mission.....	57
Strategic Approach.....	58
Strategy One.....	62
Strategy Two.....	74
Strategy Three.....	81
Strategy Four.....	92
Implementation.....	105
Priorities.....	105
Organization and Structure.....	106
Accountability and Measures of Success.....	109
Resources Required.....	109
Economic Impact Analysis.....	111
Projected Employment Impacts.....	115
Conclusion.....	121
Appendix A: Assessment of Missouri Core Research Strengths.....	A-1
Appendix B: State Investments in Life Sciences and Technology-Based Economic Development.....	B-1
Appendix C: Organizational Options for State Technology-Based Economic Development..	C-1

List of Figures

	Page
Figure 1: Average Earnings by Industry, U.S., 1998.....	1
Figure 2: Academic R&D Dollars in the Life Sciences Compared with Total Academic R&D, FY 1999	6
Figure 3: Missouri National Rankings in Life Science Fields.....	7
Figure 4: Percent Change in Life Science Academic R&D, FY 1995-1999	8
Figure 5: Life Science Subsectors, Missouri, 2001	10
Figure 6: Missouri’s Six Life Science Subsectors by Employment Size, Comparative Growth Rate, and Relative Concentration.....	12
Figure 7: Depiction of Missouri University Research Core Focus Areas	16
Figure 8: Life Science and Total Academic R&D, FY 1995-1999	30
Figure 9: Percent Change in Life Science Academic R&D, FY 1995-1999	31
Figure 10: Total R&D as Percent of Gross State Domestic Product, FY 1998.....	32
Figure 11: Academic R&D Per Capita, FY 1995-1999.....	33
Figure 12: Percent Change in NIH Dollars, Total and Per Capita, FY 1997-2000	34
Figure 13: Bioscience Venture Capital by Industry, 2001.....	38
Figure 14: National Institutes of Health Phases I and II SBIR and STTR Awards.....	39
Figure 15: Department of Agriculture SBIR Awards.....	40
Figure 16: Educational Attainment, 2000 Estimates	43
Figure 17: Bioscience Degrees Awarded, All Levels, 1999-2000 Academic Year	44
Figure 18: Missouri’s Key Gaps Along the Life Science Development Continuum	58
Figure 19: Proposed Actions to Address Key Gaps Along the Life Science Development Continuum	60
Figure 20: Missouri Institutions Collaborative Efforts Proposed for MLSRA Funding.....	71
Figure 21: Overview of Missouri’s Life Science Strategy	75
Figure 22: Missouri’s Fund of Funds	84
Figure 23: Year 10 (2012) Differences from Baseline Forecast.....	113
Figure 24: Total Employment by Scenario—Missouri Region.....	113
Figure 25: Jobs Created by Actions—Metropolitan Regions.....	114
Figure 26: Regional Product Created by Actions—Metropolitan Regions.....	114
Figure 27: Disposable Personal Income Created by Actions—Metropolitan Regions	115
Figure 28: Missouri Region Life Science Extrapolation—with Hospitals.....	117
Figure 29: Missouri Region Life Science Extrapolation—without Hospitals.....	117
Figure 30: State of Missouri Extrapolation.....	119

List of Tables

	Page
Table 1: Summary of Areas of Core Competency	17
Table 2: Life Science Regional Factors of Success.....	27
Table 3: Technology Transfer Activities in Missouri Universities in FY 1996-1999	36
Table 4: Bioscience-Related Patents, FY 1996-2000.....	36
Table 5: Bioscience Degrees, All Levels, 2000-2001 Academic Year	44
Table 6: Proposed Strategies and Actions for the Life Sciences in Missouri	60
Table 7: Recent State Bioscience and Technology Investments	67
Table 8: Proposals Submitted for MLSRA Funding, 2002	69
Table 9: Financial Requirements for “One Missouri”	110
Table 10: Missouri Region—Life Science Subsectors.....	116
Table 11: State of Missouri—Entire Economy	118

Abbreviations and Acronyms

ADC	ARCH Development Corporation
AMD	age-related macular degeneration
AUTM	Association of University Technology Managers
BCM	Baylor College of Medicine
BCMT	BCM Technologies
BFP	Ben Franklin Partnership
BSE	bovine spongiform enciphalopathy
BTB	Business and Technology Branch (Kentucky)
BU	Boston University
BUILD	Business Use Incentives for Large Scale Development Program
CAB	Center for Agricultural Biotechnology
CAES	Collaborative for Applied Experiences in Science
CAPCOs	Certified Capital Companies
CARB	Center for Advanced Research in Biotechnology
CCF	Cleveland Clinic Foundation
CED	Council for Entrepreneurial Development
CEO	Chief Executive Officer
CMB	Center of Marine Biotechnology
CMH	Children’s Mercy Hospital
CMU	Carnegie Mellon University
CNS	central nervous system
CRADAs	Cooperative Research and Development Agreements
CTF	Boston University’s Community Technology Fund
DBED	Department of Business and Economic Development (Maryland)
DCCA	Department of Commerce and Community Affairs
DNA	deoxyribonucleic acid
DPSC	Donald Danforth Plant Science Center
EBIC	Evanston Business Investment Corporation
EBTC	Edison BioTechnology Center
EDF	Economic Development Fund (Montgomery County, Maryland)
EDI	Enterprise Development, Inc. (Ohio)
EPA	Environmental Protection Agency
EPSCoR	Experimental Program to Stimulate Competitive Research (Kansas)
ETI	Edison Technology Incubator (Ohio)

FDA	Food and Drug Administration
FY	fiscal year
GIS	Geographic Information System
GMP	good manufacturing practice
HARC	Houston Advanced Research Center
HCIA	Company once known as “Health Care Investment Analysts,” later by its initials
HHS	U.S. Department of Health and Human Services
HTC	Houston Technology Center
ICAPP	Georgia’s Intellectual Capital Partnership Program
IMD	Illinois Medical District
IRB	Institutional Review Board
IT	information technology
ITEAC	Industrial Technology Enterprise Advisory Council (Ohio)
JAI	Jefferson Agricultural Institute
KCALSI	Kansas City Area Life Sciences Institute
KCOM	Kirksville College of Osteopathic Medicine
KSTC	Kentucky Science and Technology Corporation
KTEC	Kansas Technology Enterprise Corporation
KU	University of Kansas
KUMC	University of Kansas Medical Center
LIFT	Lewis Incubator for Technology (Ohio)
LSU	Louisiana State University
MABSI	Mid America Brain and Stroke Institute
MAHI	Mid America Heart Institute
MBG	Missouri Botanical Garden
MEDC	Michigan Economic Development Corporation
MEDCO	Maryland Economic Development Corporation
MEMS	micro-electro-mechanical systems
MEP	Manufacturing Extension Partnership
MIP	Maryland Industrial Partnership
MLSRA	Missouri Life Sciences Research Account
MOBIO	Missouri Biotechnology Association
MRI	Midwest Research Institute
MTC	Missouri Technology Corporation
MWSC	Missouri Western State College
NAEP	National Assessment of Educational Progress

NCBC	North Carolina Biotechnology Center
NCI	National Cancer Institute
NCSSM	North Carolina School of Science and Mathematics
NCTDA	North Carolina Technological Development Authority
NIAID	National Institute of Allergy and Infectious Diseases
NICHD	National Institute of Child Health and Human Development
NIH	National Institutes of Health
NIST	National Institute of Standards and Technology
NOLs	net operating losses
NSF	National Science Foundation
NYBA	New York Biotechnology Association
OARS	Oklahoma Applied Research Support
OCAST	Oklahoma Center for the Advancement of Science and Technology
OCIB	Oklahoma Capital Investment Board
ODOD	Ohio Department of Development
OHRP	Oklahoma Health Research Program
OMRF	Oklahoma Medical Research Foundation
OSHA	Occupational Safety and Health Administration
OSU	Oklahoma State University or Ohio State University
OTA	Office of Technology Administration
OTCC	Oklahoma Technology Commercialization Center
OTDC	Oklahoma Technology Development Corporation
OU	Oklahoma University
PET	positron emission tomography
PTIA	Pennsylvania Technology Investment Authority
R&D	research and development
RCGA	St. Louis Regional Chamber and Growth Association
REMI	Regional Economic Models, Inc.
RFP	Request for Proposal
RNA	ribonucleic acid
RTI	Research Triangle Institute
RTP	Research Triangle Park, North Carolina
RUPRI	Rural Policy Research Institute
SALSA	San Antonio-Austin Life Science Association
SATAI	San Antonio Technology Accelerator Initiative
SBIR/STTR	Small Business Innovation Research/ Small Business Technology Transfer Program

SBS	UMKC School of Biological Sciences
SEMO	Southeast Missouri State University
SI	Stowers Institute for Medical Research
SLH	St. Luke’s Hospital
SLU	Saint Louis University
SMSU	Southwest Missouri State University
SNPs	single nucleotide polymorphisms
SSTI	State Science and Technology Institute
SWOT	strengths, weaknesses, opportunities, and threats
TAB	Technology Action Board (Ohio)
TAF	Technology Action Fund (Ohio)
TBF	Technology Business Finance
TCC	Technology Commercialization Company (Ohio)
TEDCO	Maryland Technology Development Corporation
TEXAS	Toward Excellence, Access and Success Program
TGF	Technology Growth Fund (Montgomery County, Maryland)
TIGR	The Institute of Genomic Research
TMC	Truman Medical Center
TPP	Battelle’s Technology Partnership Practice
TSU	Truman State University
UCSC	University City Science Center (Pennsylvania)
UHSCOM	University of Health Sciences College of Osteopathic Medicine
UIC	University of Illinois at Chicago
UIUC	University of Illinois at Urbana-Champaign
UM	University of Missouri
UM-AES	University of Missouri-Columbia Missouri Agricultural Experiment Station
UMBC	University of Maryland Baltimore County
UMBI	University of Maryland Biotechnology Institute
UMC or UM-Columbia	University of Missouri-Columbia
UMKC or UM-Kansas City	University of Missouri-Kansas City
UMR or UM-Rolla	University of Missouri-Rolla
UMS	University of Missouri System
UMSL or UM-St. Louis	University of Missouri-St. Louis
UNC	University of North Carolina
USDA	United States Department of Agriculture
UT	University of Texas
WU	Washington University

Executive Summary

Missouri is in the midst of an economic race for the future. Stiff foreign competition continues to cut at the edges of the state’s traditional economic strengths in manufacturing, requiring firms to push toward more modernization and higher productivity, resulting in reduced jobs with greater output—just to stay in place. At the same time, industries of the future are emerging based on the technological advantages found across the United States, where states can generate high quality jobs in growing industries.

The life sciences are a major cluster of industries in which the technological superiority of the United States can sustain economic advantage and growth for years to come. The life sciences are not only about research, though advances in new fields of genetics, proteomics, tissue engineering, and computational biology are opening up exciting, new economic opportunities. The growth of the life sciences is also driven by the aging of the population, generating significant markets for new disease treatments and advanced medical services, as well as by continued population growth and the need to advance improved, high-yield food production.

It is no wonder then that more than 40 other states are looking at ways to enhance their life science base. It is not just blockbuster, highly publicized new drug companies that generate wins, but a broad range of activities.

In 2001, the State of Missouri, the University of Missouri System, the Danforth Foundation, and the Ewing Marion Kauffman Foundation initiated the development of this Life Science Strategy to guide future public and private investment decisions in Missouri. A Steering Committee was established to oversee this effort, and Battelle Memorial Institute’s Technology Partnership Practice was engaged to assist in developing the strategy.

After analyzing Missouri’s life science research base, interviewing dozens of individuals knowledgeable about the life science sector in Missouri, and comparing Missouri with a number of other states that either are or are seeking to become leading bioscience¹ centers, it is clear that

while Missouri has the opportunity to become a leading center of the life sciences in the Midwest, this will happen only if the State of Missouri, its regions, universities, research institutions, and life science companies commit to investing in and leveraging the state’s life science base over the long term. In addition, while Missouri may have a comparative advantage over its competitors due to the strength of its life science research base, the state

Examples of Other States’ Investments in the Life Sciences

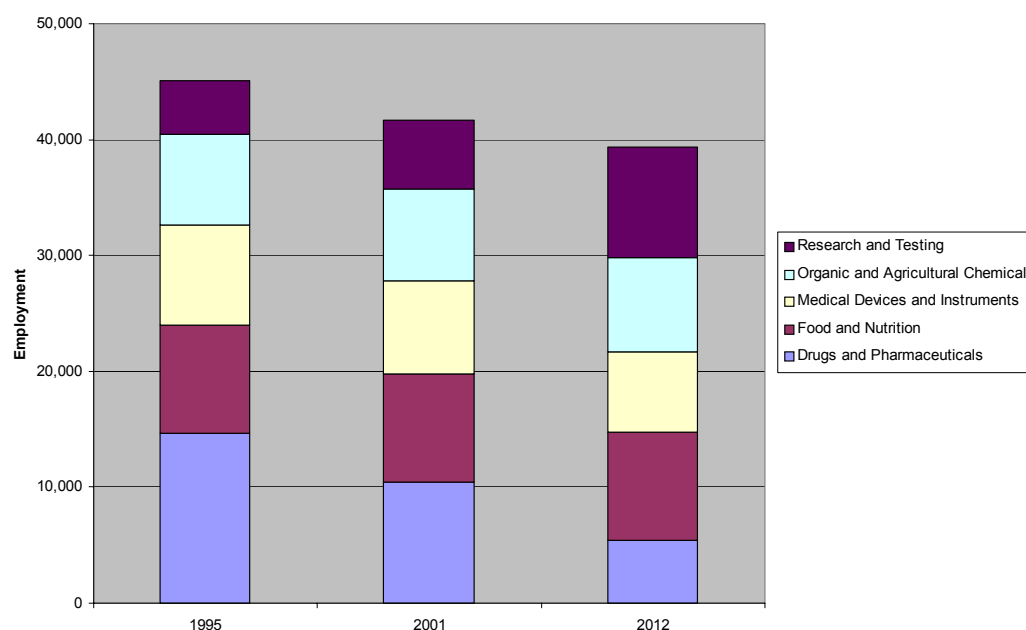
- Michigan is investing \$50 million/year for 20 years in the Life Sciences Corridor.
- Ohio is investing \$20 million to \$25 million/year in its Biomedical Research and Technology Transfer Fund.
- Pennsylvania is providing \$60 million annually for basic research; over \$160 million in one-time funds for bioscience-related venture funds; and is establishing three Life Sciences Greenhouses.
- California is investing \$100 million in a bioengineering and biotechnology institute, and \$500 million in pension funds towards the California Biotechnology Program.
- Texas appropriated \$800 million for seven new or expanded health science research centers.
- Wisconsin launched BioStar, a \$317 million, 10-year research initiative, and has created the Wisconsin Investment Board with \$50 million in pension funds.

¹ The terms “bioscience(s)” and “life science(s)” are used interchangeably in this report.

will need to continue to build its R&D base and accelerate the movement of research findings into the marketplace to compete successfully with leading life science regions and other states vying to become life science centers.

Recent state actions and proposals, however, suggest no full understanding of the costs of not moving forward and making key investments in the life sciences. If the growth of Missouri’s life science sector continues at the same rate experienced from 1995–2001, the state will lose more than 9,000 jobs in drugs and pharmaceuticals and nearly 1,800 jobs in medical devices and instruments during the next decade. In addition, Missouri will experience very slow growth in the mainstays of state’s economy—food and nutrition and organic and agricultural chemicals (see Figure ES-1).

Figure ES-1: Projected Missouri Employment in the Life Sciences (excluding hospitals)



On the other hand, Battelle projects that *if this strategy is implemented promptly, Missouri will add more than 21,000 permanent, mostly high-paying jobs in the life science industries. During the 10 years from 2003 until 2012, the Missouri region will have gained nearly \$7.2 billion in Gross Regional Product and more than \$3.9 billion in real disposable personal income.* Failure to act may mean that Missouri will be left behind in the race to develop a vibrant, high-paying life science sector.

Missouri must make critical investments in the future to become a leader in tomorrow’s life science economy. Life sciences represent a clear path for building “One Missouri”—one that benefits rural and urban areas alike, takes full advantage of current state investments in higher education to maximize their return in terms of wealth and jobs, and builds on a traditional bioprocessing base around newer life science breakthroughs. This report outlines the strategies and actions that must be undertaken to position Missouri to become a leader in the life sciences.

SUMMARY OF KEY FINDINGS

Missouri has a significant R&D base in the life sciences that is growing rapidly, but Missouri is not yet among the first tier of states in overall university life science funding.

The life sciences dominate university research efforts in Missouri. Roughly \$8 out of every \$10 in university research are spent on life science research, according to data from the National Science Foundation (NSF). Despite this strong concentration of its research efforts in the life sciences, Missouri currently stands in the second tier of states in overall university life science research. In university research expenditures from all sources, according to NSF data, Missouri ranks 12th in overall life science research funding. This is primarily due to the presence of Washington University (WU). In FY 2000, Missouri received \$367 million in NIH awards. Of this amount, however, more than 75 percent went to WU. Missouri’s other universities received only \$87.5 million in NIH funding in FY 2000. If WU is excluded, Missouri drops to 29th in total life science R&D spending among the 50 states.

Strengths

- Fast growing and sizable life science research base
- Broad distribution of educational, medical center, and agricultural bioprocessing capabilities
- Private sector and nonprofit firms that serve as life science anchors.
- Community leadership and support has emerged in the State’s two largest regions
- Niche strategies have developed in the smaller regions
- Strengths in information technology to support development of life sciences

However, overall life science research growth in Missouri is outpacing the nation and many leading states. Missouri experienced extremely rapid growth in NIH funding, with total NIH awards increasing by more than 35 percent between 1997 and 2000. In addition, life science research in Missouri in the years ahead will greatly benefit from the recent formation of two major nonprofit research institutions destined to join the ranks of world-class, nonprofit life science research institutes—the Donald Danforth Plant Science Center and the Stowers Institute for Medical Research. It is expected that these two institutions together will add in excess of \$100 million in annual life science research to Missouri.

Except for Washington University, the state’s life science research base has experienced underinvestment, and consequently is not fully developed.

The universities’ ability to compete successfully for research funding depends to an extent on their abilities to attract world-class faculty and to provide the laboratories and state-of-the-art equipment to conduct cutting-edge research. Yet, Missouri has not invested sufficiently in building the universities’ research capabilities. Missouri’s facility funding, for example, suffers from having only one-year budgets that get reprioritized each year and provide less than full funding for facilities, which causes delays in completing projects.

Missouri’s universities have few resources dedicated to technology transfer and commercialization, and the interface with industry clients is weak.

While Washington University has been very effective in terms of licensing technology and has had some success in spinning off new start-up companies, other Missouri institutions have been less successful in their technology transfer efforts. Between FY 1996 and 1999, Washington University executed 2.03 licenses per \$10 million of R&D expenditures and spun off nine start-up companies. During the same time period, the University of Missouri System executed 0.95 patents per \$10 million of R&D expenditures and spun off one start-up company.

Interviews with business executives indicated that Missouri companies are not partnering with Missouri’s research institutions to the extent that they might and Missouri has provided limited staffing and dedicated resources to support commercialization activities or to encourage greater interaction between university researchers and industry.

Missouri has a sizable industry base in the life sciences on which to build; however, Missouri’s growth in the life sciences is being driven by the state’s large and growing hospital and medical laboratory subsector.

Missouri’s life science sector consists of 1,815 establishments employing more than 193,000 workers. Overall, private sector life science employment stands 14 percent above the concentration found nationally. More impressively, growth in the Missouri life science sector was 11 percent compared with 7.3 percent nationally. These overall figures, however, mask some key trends and developments.

**Missouri’s Life Science Profile
excluding Hospitals (2001)**

- 889 establishments
- 41,635 employees
- 7.6 percent employment decline, '95-'01
- 29.2 percent establishment increase, '95-'01
- Location quotient 0.95
- 1.2 percent of private sector employment

When hospitals and laboratories are excluded, the Missouri life science sector has performed below the national level in recent years.

Missouri’s life science sector, excluding hospitals and laboratories, consists of 889 establishments and greater than 41,000 life science workers. Between 1995 and 2001, the Missouri life science sector decreased its employment level by 7.6 percent compared with a national growth rate of 18.8 percent. This was slightly less than Missouri’s overall decline in total manufacturing employment of 9.2 percent.

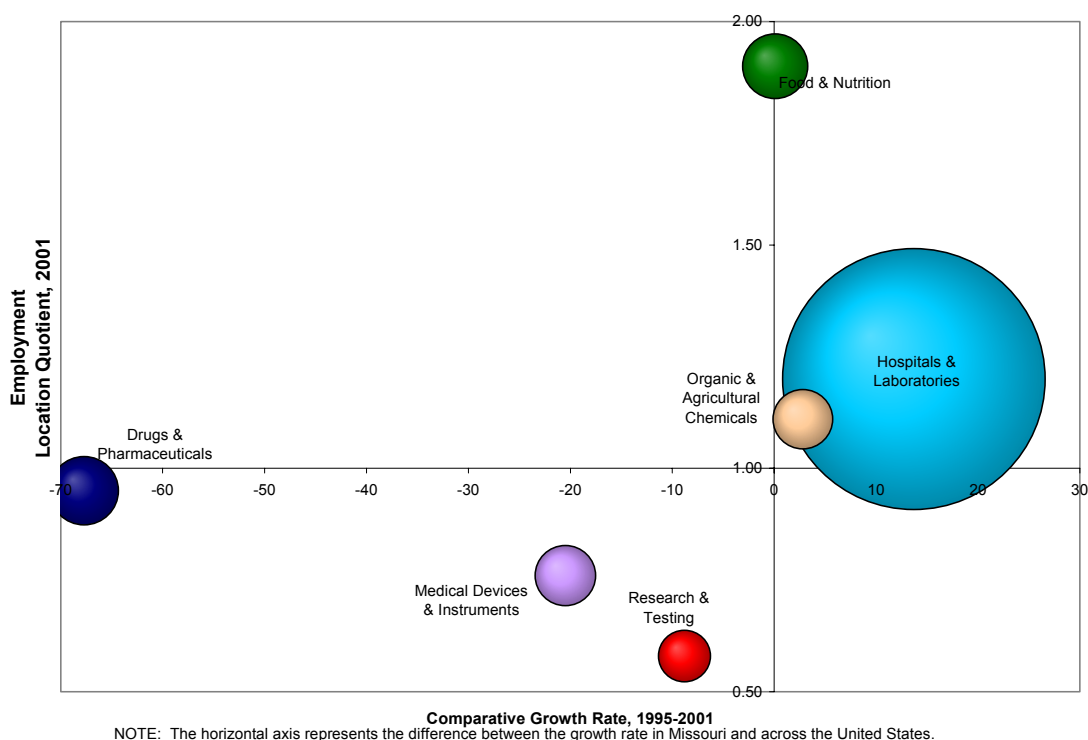
Missouri’s greatest strengths in the life sciences are found in bioprocessing manufacturing.

With nearly double the national employment concentration, the food and nutrition subsector is the strongest Missouri life science specialization. A primary industry strength is found in agricultural chemicals with a concentration nearly three times the national average—this industry employs 3,200 workers, more than double its Missouri employment level just six years ago.

The subsectors currently demonstrating strength within the Missouri life science sector are those that tend to be less technology-intensive and have less economic impact potential.

Figure ES-2 depicts the six Missouri life science subsectors classified by employment size, comparative growth rate, and relative concentration. The area of each disk corresponds to the amount of employment in that sector. Although most of the sectors are near the national level of concentration, food and nutrition is almost double, whereas life science research and testing is only slightly above half. Both organic and agricultural chemicals and hospitals and laboratories are growing more rapidly within Missouri than across the nation, but medical devices and instruments, research and testing, and especially drugs and pharmaceuticals are behind the national pace of growth.

Figure ES-2: Missouri Life Science Sectors



Perhaps most importantly, the three sectors in the bottom left quadrant of the figure, with lower than average concentrations and negative comparative growth rates, are usually considered to be the higher technology and more economically influential life science subsectors. Food and nutrition in particular is less technology-based than the other life science subsectors, while the hospital and laboratory industries do not tend to be influential economic drivers or generate substantial life science employment outside of the subsector.

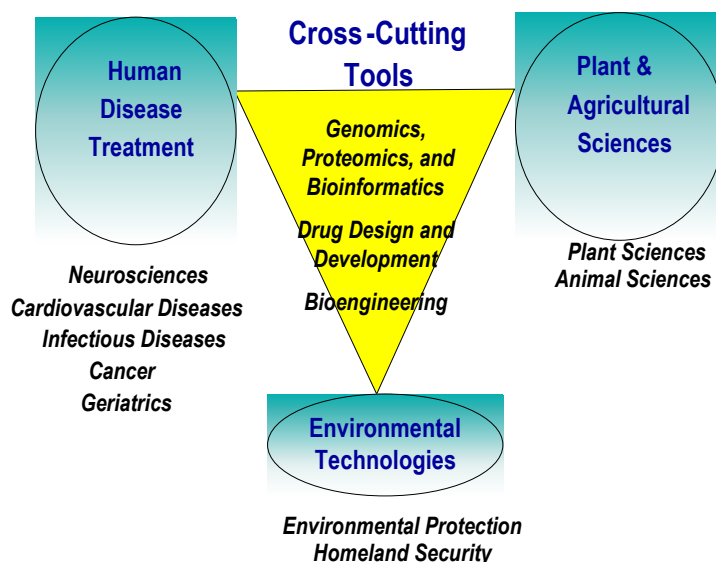
Missouri’s future requires it to move more of its industries toward the upper right quadrant if it is to be a major player in the life sciences.

Missouri has developed areas of research strength in two areas: plant and agriculture-related sciences and human disease treatment. A third, less-developed and potential emerging area is environmental life sciences.

Missouri has major strengths in plant science, focusing on crop improvements, improved human health and industrial uses of crops, along with a focused strength in animal science technologies. A second area of research strength is human disease treatment, involving specific disease areas of neurological and psychiatric disorders, infectious diseases, cardiovascular, reproduction, geriatrics, and cancer. A third, less-developed and potential emerging area is environmental technologies, with a concentration in the Rolla/Fort Leonard Wood region involving environmental protection as well as homeland security. Saint Louis University, with its center for the Study of Bioterrorism and Emerging Infections, and Midwest Research Institute also are positioned to play a national role in biological and chemical defense.

Missouri also has emerging strengths in the life science research tools necessary to support these key research areas. They include genomics, proteomics and bioinformatics, drug design and development, and bioengineering (Figure ES-3).

Figure ES-3: Depiction of Missouri University Research Core Focus Areas



Community leadership and support have emerged in the state’s two largest regions as a result of undertaking life science strategies, in addition to the niche strategies that have developed in the smaller regions.

The St. Louis Regional Chamber and Growth Association (RCGA), in concert with Civic Progress, has developed and, with the Coalition for Plant and Life Sciences, is implementing a strategy to position St. Louis as the international center for the plant sciences and a major international center in the life sciences. Kansas City also has initiated and completed a regional life science strategy. The Kansas City Area Life Sciences Institute (KCALSII) is a not-for-profit corporation that has been established to implement a strategy to foster collaboration and resource

sharing between the area’s private sector, academia, and government. Other regions of Missouri also offer opportunities in the life sciences. For example, the St. Joseph area, which is becoming a center for the animal sciences, commissioned the development of a life science strategy. Cape Girardeau is emphasizing field trials and new varieties of rice and other agricultural crops; and Kirksville, with its higher education and medical presence, is similarly developing a focus in the life sciences, as is Joplin.

The state’s financial markets are not sufficiently developed to encourage private sector venture investments in the life sciences (although St. Louis has achieved some recent success), and significant gaps exist in pre-seed/seed, angel, and later-stage investing for the life sciences.

Between 1995 and 2001, \$146.7 million was invested in Missouri life science companies. More than half of this investment was made during the 2000–2001 time period. In 2001, Missouri life science companies received \$42 million in venture capital. In comparison, life science companies in Pennsylvania, North Carolina, and Maryland received venture capital investments of \$171 million, \$158 million, and \$127 million, respectively in 2001. Missouri also differs from these states in the distribution of venture capital investments by sector. Of the total dollars invested between 1995 and 2001, 55 percent of the funds went to medical device and equipment companies and 20 percent was invested in biopharmaceutical companies. Maryland life science venture capital investments, in comparison, are heavily focused on the biopharmaceutical sector, while Pennsylvania has significant levels of investment in both biopharmaceuticals and medical software and information. While life science venture capital investments are increasing, Missouri still lacks lead venture capital firms for life science investments.

There is insufficient wet-lab space for firms to start up, expand, and grow.

The availability of specialized lab space needed by life science companies has been a concern across Missouri. In St. Louis, a study completed in October of 2001 documented an expected need within the next three years for 252,200 square feet of lab space, including 138,500 square feet of wet-lab space, based on information provided by 24 companies. Similarly, for other areas of the state, recent focus group meetings with industry identified specialized lab space as a key life science development issue across Missouri.

Weaknesses

- The state’s life science research base has experienced underinvestment, and consequently is not fully developed.
- Missouri’s universities have few resources dedicated to technology transfer and commercialization, and the interface with industry clients is weak.
- The state’s private sector base is not strong in emerging life science fields.
- The public sector is not sufficiently focused to foster its life science resources, and the state lacks a systematic “tool kit” of assistance to attract firms and encourage their growth.
- The state’s financial markets are not sufficiently developed to encourage private sector venture investments in the life sciences; and significant gaps exist in pre-seed/seed, angel, and later-stage investing.
- The state is facing severe budget constraints.
- There is insufficient wet-lab space for firms to start up, expand, and grow.
- Barriers and silos within and among Missouri’s institutions and organizations may be the state’s undoing in positioning itself in the life sciences.

The state is facing severe budget constraints that will make it difficult to invest at the level required to position Missouri as a strong competitor in the life sciences.

In FY 2002, Missouri was forced to cut \$750 million from its enacted FY 2002 budget.² This was the sixth largest budget cut among the 50 states in a year in which states faced serious fiscal crises. For FY 2003, Missouri is facing a budget deficit of approximately half a billion dollars. Governor Holden has proposed \$612 million in cuts in the state’s General Revenue core funds, with \$133 million of the total made up from the state’s rainy day fund.³ The Governor is also supporting legislation that would allow Missouri to securitize the state’s tobacco settlement to access additional resources at this time.

The newly established Donald Danforth Plant Science Center and Stowers Institute for Medical Research can help uniquely position Missouri and build the state’s image as a life science center.

Both the Donald Danforth Plant Science Center and Stowers Institute for Medical Research are truly unique institutions that provide an opportunity to put Missouri on the map in terms of the life sciences. The Donald Danforth Plant Science Center is an innovative partnership joining the Missouri Botanical Garden, Monsanto Company, Purdue University, the University of Illinois at Urbana-Champaign, the University of Missouri-Columbia, and Washington University in St. Louis. Established in 1998, the center aims to become the premier research center dedicated to plant sciences. The Stowers Institute for Medical Research in Kansas City is committed to becoming one of the most innovative biomedical research facilities in the world. The current endowment of the institute is \$1.6 billion. It is estimated that these two research centers will employ approximately 500 researchers and add \$100 million annually to Missouri’s R&D base.

Opportunities

- Donald Danforth Plant Science Center and Stowers Institute for Medical Research can help uniquely position Missouri.
- Increases in federal life science R&D funding present opportunities for Missouri research institutions.
- Missouri can build on regional strategies found across the state and facilitate connections across regions.
- The state’s environmental life science sector can be built by capitalizing on the presence of Fort Leonard Wood.

There is an opportunity to build on regional strategies found across the state and to facilitate connections across regions.

St. Louis adopted a Plant and Life Sciences Strategy in 2000 and has proceeded rapidly with implementation. The region has initiated an aggressive BioBelt marketing campaign, and progress has been made on attracting life science investment funds to the region. In Kansas City, KCALSI has been created to attract research funding by encouraging collaboration among the region’s universities, research institutions, and hospitals. Similar efforts are underway elsewhere in the State. For example, in St. Joseph, the St. Joseph Area Chamber of Commerce, in cooperation with Missouri Western State College (MWSC) and Heartland Health, has formed a Life Sciences Network to bring existing life science industries, MWSC, and Heartland together

² National Governors’ Association and National Association of State Budget Offices, *Fiscal Survey of the States*, November 2002.

³ *The Missouri Budget: FY 2003 Budget Summary*, www.oa.state.mo.us/bp/budg2003/.

to cultivate the region’s existing life science sector and to develop strategies to grow the life science industry in the future.

There is an opportunity to build the state’s environmental life science sector by capitalizing on the presence of Fort Leonard Wood and other Missouri institutions, such as the Midwest Research Institute, that are active in environmental life sciences.

Environmental life sciences refer to the application of life science for environmental purposes. Environmental life science covers a wide range of life science applications, from the biochemical analysis of water, air, soil, and waste products to the design of pesticides and herbicides, from food contamination testing to the genetic construction of microbes for use in environmental remediation. Fort Leonard Wood is home to the Army’s Environmental and Chemical Schools, which train Army personnel to carry out assignments involving environmental and chemical activities such as dealing with hazardous materials, bioremediation, and first response teams. Recently, Fort Leonard Wood was designated as the Army’s Environmental Integration Command, which is responsible for setting out the doctrine, training, and organizational approaches on environmental issues for the Army. With the increased emphasis being placed on bioterrorism and homeland security, activities at Fort Leonard Wood are likely to increase, offering additional opportunities for nurturing the development of an environmental life science sector in Missouri.

Other states are investing more and for longer periods of time in the life sciences, and Missouri’s financial constraints make it hard to catch up.

States such as Michigan, North Carolina, Maryland, and Pennsylvania are investing aggressively in a comprehensive range of programs designed to create university/industry partnerships in the biosciences and to assist start-up and growing bioscience companies. Other states such as Georgia and Ohio are aggressively pursuing life science development strategies, including strengthening research, increasing university/industry collaborations, and beefing up their business development support. Missouri will have to invest significant resources in the life sciences just to keep even with these states, let alone surpass their efforts.

Threats

- Other states and regions are aggressively pursuing life science development.
- Failure to capitalize on the opportunities the tobacco settlement provides could strike a fatal blow to developing the life science sector.
- Multistate base can be an impediment to achieving consensus and action, and adds complexity to implementation.
- The state’s risk-averse culture and lack of knowledge and understanding of the life science industry could constrain action.

Failure to capitalize on the opportunities the tobacco settlement provides could strike a fatal blow to developing Missouri’s life science sector.

Missouri is one of approximately 18 states that has dedicated some portion of its tobacco settlement dollars in the past to life science research.⁴ Unlike some of these states, which have enacted legislation dedicating a portion of their tobacco settlement funds on a permanent basis, Missouri failed to pass a bill that would have dedicated a specific percentage of Missouri’s tobacco settlement funds for the life sciences permanently. Using a portion of the state’s tobacco settlement dollars or other revenue source is critical in Missouri, given the state’s fiscal situation and limitations on the state’s ability to raise revenues.

⁴ As of the Spring of 2002.

PROPOSED APPROACH

Missouri has a number of strengths for positioning itself as a life science-driven economy, but the state also has a number of weaknesses that must be addressed if Missouri is to achieve its goal of becoming a center of the life sciences (see Figures ES-4 and ES-5). First and foremost, Missouri must continue to build its research capacity in the life sciences, investing in its research institutions to enable them to compete for a greater share of life science R&D funding. Second, as the research base grows, emphasis should be placed on encouraging technology commercialization and fostering the growth of new life science companies. Third, Missouri must attract new life science companies; help existing companies to grow; and capitalize on its strong industry anchors, which include Monsanto, Bayer, Midwest Research Institute, Phoenix, and others.

Figure ES-4. Missouri’s Key Gaps Along the Life Science Development Continuum

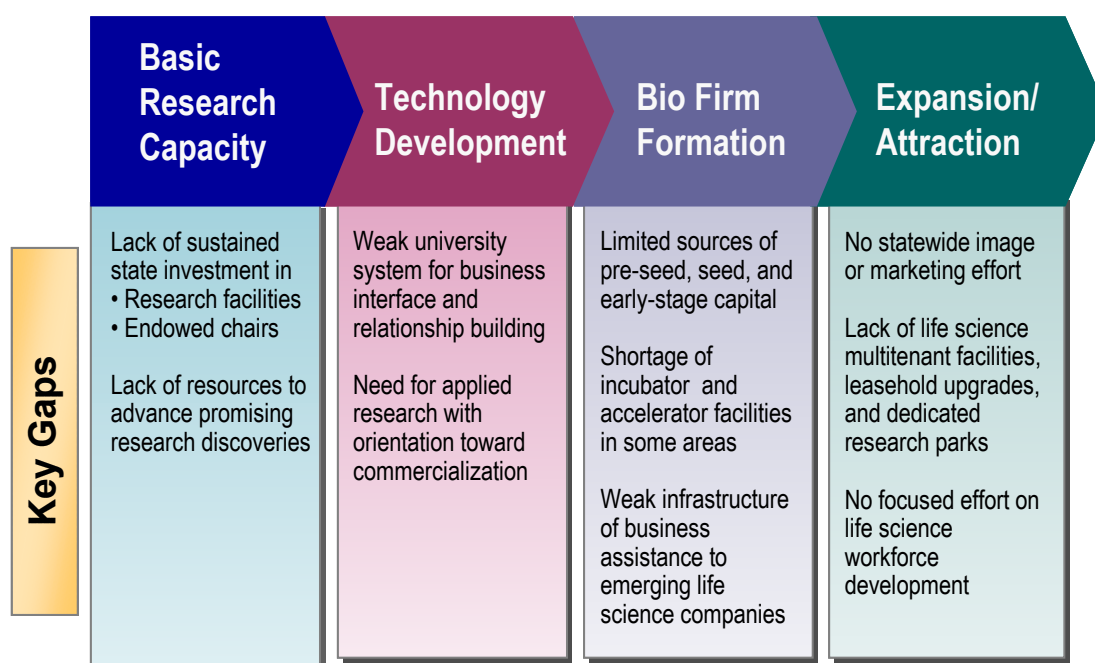
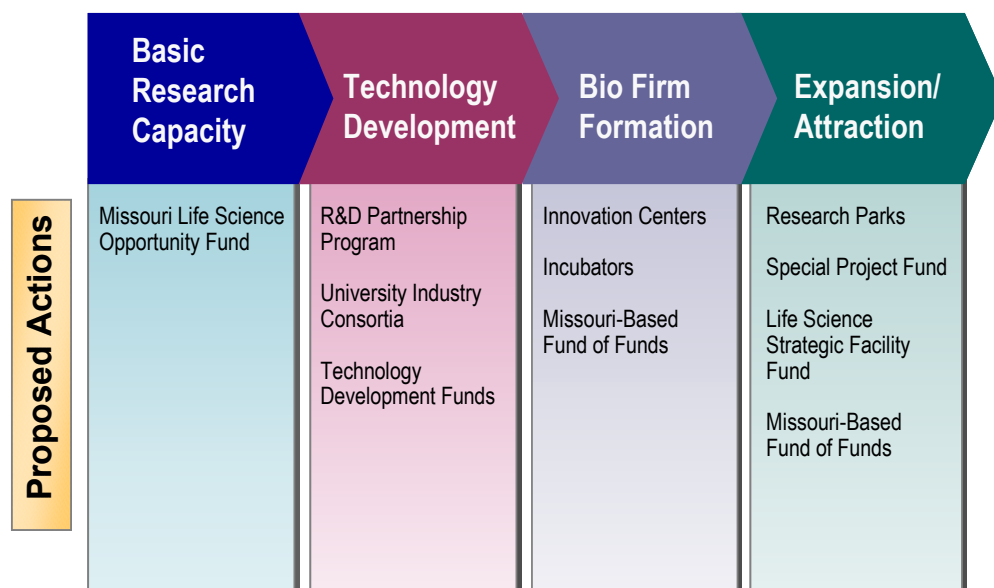


Figure ES-5. Proposed Actions to Address Key Gaps Along the Life Science Development Continuum



Most urgently, Missouri must be proactive, leaving no doubt of the state’s commitment to the life sciences. The actions and efforts undertaken during the next decade likely will decide Missouri’s future position in the life sciences.

VISION AND MISSION

The future vision for the life sciences is bold and far-reaching, yet achievable. This vision can take Missouri into the next decade.

Missouri will be a leading Midwest life science center, among the nation’s and world’s leaders, in plant, animal, and human health, recognized for its world-class research and exceptional ability to commercialize research discoveries into new products and services.

Missouri will be home to leading-edge researchers and leading-edge firms whose discoveries and products contribute to both a healthy citizenry and a healthy economy, driven by the state’s life science base.

To achieve this vision, the following mission is proposed:

Missouri will invest from many sources (state, federal, philanthropic, industry) to enhance its research base through private/public partnerships to ensure world-class leadership in core research fields. Missouri also will encourage collaboration among and between its research institutions, industry, and established value-added intermediary organizations. Technology commercialization efforts will be enhanced and expanded so as to increase the rate of commercial application from research, resulting in significant growth in firms, jobs, and wealth for the state and its citizens.

STRATEGIC PLAN TO BUILD “ONE MISSOURI”

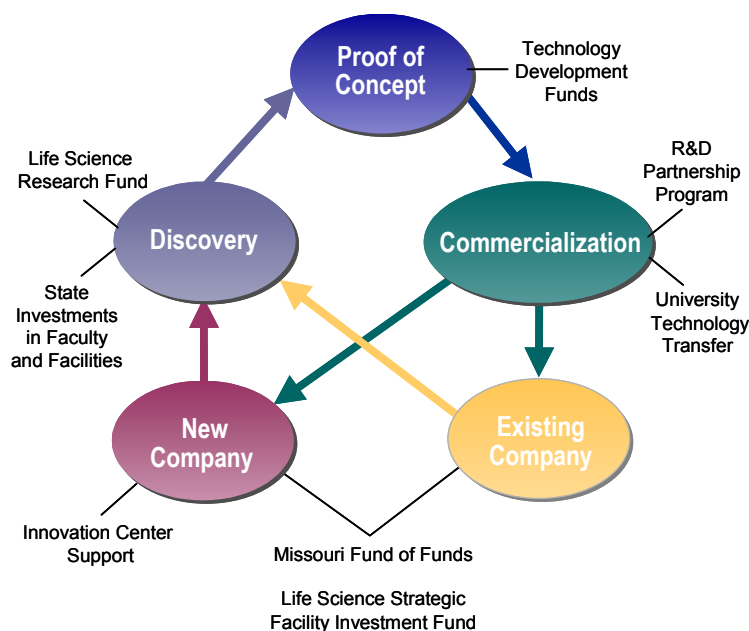
The strategy, *Life Sciences & Missouri’s Economic Future: An Opportunity to Build “One Missouri,”* is a three-prong approach to promote technology-based development in the state through increasing research capacity, aggressively implementing economic development initiatives, and striving to improve the technical aptitude of the state’s workforce.

Missouri has the opportunity today to develop a world-class life science sector for the future. However, to become a leading life science center will require that Missouri focus its efforts, investments, and initiatives in three key areas:

- Building life science research capacity;
- Supporting the development of a critical mass of life science companies; and,
- Developing the supply chain of talent that will enable the life science sector in Missouri to grow and succeed.

Under the rubric of these three areas of emphasis, Battelle proposes four strategies, encompassing 20 actions detailed in the full report, to achieve Missouri’s Bioscience Vision for the future (see Figure ES-6).

Figure ES-6. Overview of Missouri’s Life Science Strategy



The plan is further outlined in Table ES-1.

Table ES-1: Summary of Proposed Three-Prong Approach and Actions for the Life Sciences in Missouri

Three-Prong Approach	Action	Priority
Prong One Build life science research capacity by enhancing the capacity of the state’s higher education and research institutions to undertake, in collaboration with industry, world-class research in areas of core competency.	Release funding and eliminate matching requirements for legislatively approved capital projects of the University of Missouri System that build capacity in the life sciences.	Immediate
	Create a Missouri Life Science Opportunity Fund that would invest in higher education and nonprofit research facilities, faculty/endowed chairs, and life science equipment.	Immediate
	Establish an R&D Partnership Program to encourage collaborations between the state’s higher education and research institutions and industry.	Mid-Term
	Provide funding to universities and research institutions to form joint consortia with industry clusters to pursue joint ventures and major funding opportunities.	Mid-Term
	Work with Missouri’s and neighboring states’ Congressional Delegations to secure federal funds and projects that further build the state’s life science base.	Mid-Term
Prong Two Support the development of a critical mass of life science companies by focusing on commercialization and access to capital for new firm creation, expansion, and recruitment, in addition to creating a supportive business, tax, and regulatory climate for life science companies, and a national and international image as a leading center in the life sciences.	Revise and expand the mission of the Innovation Centers to provide in-depth assistance to technology entrepreneurs and make their services available statewide by establishing satellite operations in the second-tier metropolitan areas.	Immediate
	Establish new and expand existing life science wet-lab incubators and accelerators in areas with potential to develop firms in niche markets.	Short-Term
	Create and invest (through appropriations or tax credits) in Technology Development Funds that would operate through appropriate third-party mechanisms in each major region of the state.	Immediate
	Review university policies and practices (distribution of royalties, disclosures, etc.) and revise as necessary to encourage and provide incentives to faculty to commercialize their technology through spin-offs or licensing to industry.	Short-Term

Table ES-1: Proposed Three-Prong Approach and Actions for the Life Sciences in Missouri (continued)

Three-Prong Approach	Action	Priority
Prong Two (continued)	Create a large-scale (\$150 million to \$200 million), Missouri-based “fund of funds” to serve as a vehicle for institutional investment of all kinds in private equity funds and encourage Missouri’s public pension fund boards to allocate a small portion of their pension assets to this fund.	Immediate
	Pursue a comprehensive approach to address life science companies’ specialized facility requirements, financing for leasehold improvements, multitenant life science facilities, and research park development.	Mid-Term
	Make changes in Missouri’s tax structure to provide incentives for the growth and development of the state’s bioscience base.	Immediate
	Establish a Life Science Special Project Fund through MTC for large-scale, nonuniversity projects to retain, attract, and expand firms in the state.	Mid-Term
	Develop a statewide image, marketing, and business development effort that builds on and supports current regional efforts to market Missouri as a center for the life sciences.	Immediate
	Initiate a statewide education campaign on the benefits and importance of the life sciences to the state’s economic future.	Mid-Term
Prong Three	Improve math and science education at the K-12 level by exploring innovative methods to promote excellence.	Short-Term
Develop the supply chain of talent that will enable the life science sector in Missouri to grow and succeed by Increasing the connectivity between life science employers and educators and encouraging students and workers to pursue careers and opportunities in the life sciences.	Provide incentives to higher education institutions to work with industry to review and adopt new multidisciplinary curricula, and provide innovative workforce programs in the life sciences.	Immediate
	Initiate a yearly workforce survey of the state’s life science industry to assess demand for various skills, positions, and careers and convey this information to education and workforce providers.	Immediate
	Offer year-round internships and co-op opportunities to higher education students in firms, nonprofits, and other life science organizations.	Mid-Term
	Support, market, and expand the Advantage Missouri Program, in the life sciences, for individuals that stay in the state upon graduation.	Mid-Term

IMPLEMENTATION

The life sciences hold great potential for the State of Missouri. The industry is expanding rapidly, and Missouri is positioned to continue to grow its life science research base and capitalize on its commercial potential. Competing for leadership in the life sciences, however, will not be easy and will require significant commitments from Missouri’s public, nonprofit, and private sectors. Missouri is fortunate in that (1) its two major metropolitan areas, St. Louis and Kansas City, have committed to developing their life science sectors and (2) other regions of the

state, such as St. Joseph and Rolla/Springfield, have developed strengths in key life science areas. For these initiatives to succeed and for their impact to be felt across all regions of Missouri, the State of Missouri must commit both leadership and resources to making Missouri a leader in the life sciences.

Priorities

Nine of the 20 actions should be considered immediate priorities to be addressed over the next two years:

1. Release funding and eliminate matching requirements for legislatively approved capital projects of the University of Missouri System.
2. Create a Missouri Life Science Opportunity Fund that would invest in the research base of the state.
3. Revise and expand the mission of the Innovation Centers to provide in-depth entrepreneurial assistance services, incubator operations, research park development, and the establishment of satellite operations.
4. Create and invest (through appropriations or tax credits) in Technology Development Funds.
5. Create a large-scale (\$150 million to \$200 million), Missouri-based “fund of funds” to serve as a vehicle for institutional investment of all kinds, including public pension funds, in private equity funds that in turn invest in life-science start-ups and in the real estate necessary to house them.
6. Make changes in Missouri’s tax structure to provide incentives for the growth and development of the state’s bioscience base.
7. Develop a statewide image, marketing, and business development effort in concert with regional efforts underway.
8. Provide incentives to higher education institutions to work with industry to review and adopt new multidisciplinary curricula, including offering related degrees and certificates, and provide innovative workforce programs in the life sciences.
9. Initiate a yearly workforce survey through MO BIO of the state’s life science industry to assess demand for various skills, positions, and careers and convey this information to education and workforce providers.

Organization and Structure

Implementing the Missouri life science strategy will require both staff and resources. One or more entities must be designated to take the lead on implementing the various initiatives proposed in the strategy, and an organization must be given responsibility for overseeing overall implementation. States use three models of organizations to implement technology-based economic development programs. They can be housed within an existing state agency, established as an independent state agency or commission, or lodged in a private nonprofit corporation.

Several options could be considered:

1. The Office of Science and Technology in the Department of Economic Development could be expanded and given responsibility for implementing the strategy and undertaking many of the proposed strategies and actions.
2. The Governor could appoint a Science Advisor and create an Office of Science and Technology within the Governor’s Office to implement the strategy.
3. The Missouri Technology Corporation (MTC), a 501 (c) 3 nonprofit corporation established in 1994 to promote the development of Missouri’s economy through the application of science and technology, could serve as the vehicle to oversee and implement the life science strategy.

The drawback of the first two options is that both would require hiring additional state employees at a time of severe budget constraints. In addition, states have generally found that, by having the lead science and technology programs outside state government, the programs can (1) have higher credibility with the business community, (2) attract and retain quality staff since they are not under civil service salary restrictions, and (3) be more flexible and responsive to business needs. Using MTC to implement the strategy poses a problem because MTC currently has no staff or operational responsibilities. The best alternative for Missouri might be to combine the second and third options by having a science advisor who would also serve as the CEO of MTC.

Studies of strategic planning suggest that a critical success factor is the presence of a champion who has the ability to bring together key stakeholders and mobilize various institutions to implement the strategy. ***It is proposed that the Governor create the position of Governor’s Science and Technology Advisor and lodge responsibility for overseeing implementation of this strategy with this position.*** The Science and Technology Advisor should be a nationally recognized scientist who has served in senior positions within both academia and industry. The appointment of a Governor’s Science and Technology Advisor will be a visible sign by the Governor that he is committed to making Missouri a leading center of the life sciences in the Midwest.

It is also proposed that the Governor’s Science and Technology Advisor serve as the CEO of the Missouri Technology Corporation, which should assume responsibility for implementing the actions in this strategy. MTC currently advises both the Department of Economic Development and the Governor regarding business development opportunities related to new technology and products.

It is proposed that the responsibilities of MTC be expanded and that funding be provided to enable the Governor’s Science and Technology Advisor to use MTC as an implementation arm and to hire staff to implement the actions proposed in this strategy. It is estimated that \$1 million annually will be required to support the operations of MTC and the Governor’s Science and Technology Advisor. Given that MTC is a private nonprofit, some of this funding could come from the private sector, in addition to the funding provided by the legislature.

Missouri has the basis for a strong delivery system to implement this strategy, including

- Four Innovation Centers, which if properly staffed with enhanced responsibilities can serve as primary regional coordinators and connectors

- MO BIO, which has emerged as a strong statewide advocate for the bio and life sciences with strong membership growth
- Strong regional organizations in the state’s two largest metropolitan areas, including the St. Louis Regional Chamber and Growth Association and the St. Louis Plant and Life Sciences Coalition in St. Louis and KC Catalyst and the Kansas City Area Life Sciences Institute in Kansas City, both with adopted life science strategies being actively implemented.
- Emergence of interested regional groups and organizations in other rural and smaller metropolitan regions of the state, each with an important role to play in building “One Missouri.”

Accountability and Measures of Success

It is recommended that the following measures be used to gauge success and progress in implementing Missouri’s life science strategy:

- Amount of, and increase in, life science R&D funding in the state
- Reputation and stature of the state’s research institutions in the life sciences as measured by citation analysis, funding, and reputation rankings
- Growth in the state’s life science economic base: number of firms, their employment, their concentration in the state relative to the nation, and birth and death rates of firms
- Level of, and increase in, life science venture capital invested in Missouri companies
- Funds leveraged to implement this strategy (all sources)
- Progress in implementation of the actions (monitor and chart progress).

In addition, this strategy should be reviewed and updated every three to five years as markets change and progress is made.

Resources Required

The total annual cost of implementing the proposed strategies and actions is estimated to be between \$144 million and \$158 million. One-time costs, which would be spread over a five-year period, total \$125 million. It is proposed that these funds be drawn from a combination of sources including dedicated tobacco settlement funds, revenue from cigarette taxes, direct appropriation by the legislature, bonding, and tax credits. Identifying funding streams is of critical import due to the reappropriation of the tobacco settlement funds and the failure of the Health Life Science ballot initiative. In addition to these costs, it is anticipated that \$150 million would be provided by means of state pension fund investments in a Missouri Fund of Funds.

Economic Impact

The strategies and actions outlined in the preceding sections were analyzed using the Policy Insight dynamic economic impact model created by Regional Economic Models, Inc. (REMI) to estimate the likely economic impacts of the directed investments made by the state government of Missouri. If the action items are acted upon as envisioned, the economic impact by year 10 will be (Figure ES-7):

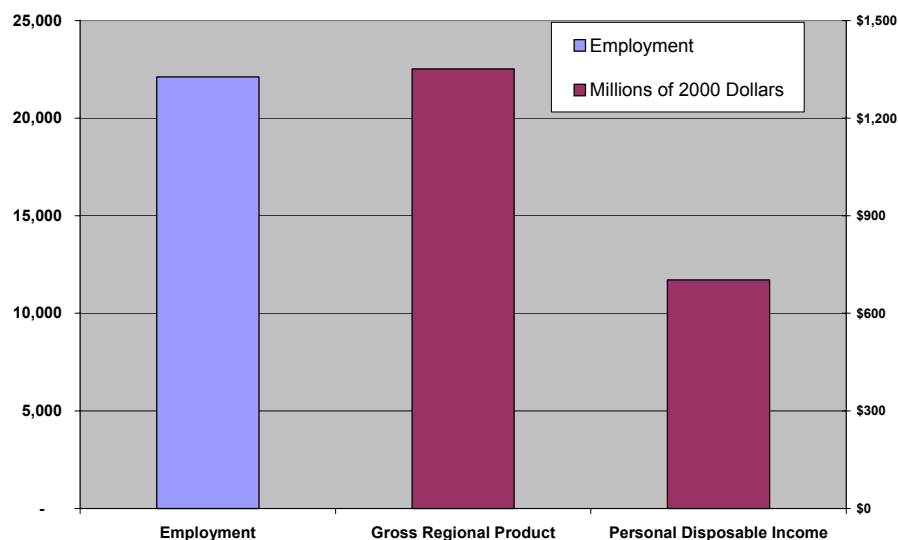


Figure ES-7: Year 10 (2012) Differences from Baseline Forecast

- 22,110 jobs created
- \$1.351 billion in Gross Regional Product
- \$703 million in real disposable personal income.

These figures are additional to the baseline economic forecasts—i.e., they represent changes that will occur in the economy only if the actions are taken.⁵

CONCLUSION

The State of Missouri is fortunate to possess strong assets in the life sciences that offer tremendous potential for the state’s economy. The various metropolitan regions already have developed and begun implementing life science strategies that the State of Missouri can build upon and leverage in its own statewide strategy. However, to accelerate the regional agendas and establish Missouri as the Midwest’s leading center for the life sciences, the state must act aggressively.

Recent state actions and proposals suggest that there is not a full understanding of the costs of not moving forward and making key investments in the life sciences beginning now—not two years or five years from now. Battelle projects that ***if this strategy is promptly implemented during the 10 years (from 2002 until 2012), the Missouri region will have gained nearly \$7.2 billion in Gross Regional Product and more than \$3.9 billion in real disposable personal income.*** Depending upon the continuation of these actions and programs past year 10, annual gains should continue beyond year 10 as well, though this model cannot provide such forecasts. Failure to act may mean that Missouri will be left behind in the race to develop a vibrant, high-paying life science sector.

⁵ The economic impact analysis was conducted in May 2002 and was not updated for the final release of the strategy in January 2003.

Missouri must make critical investments in the future to become a leader in tomorrow’s life science economy. Life sciences represent a clear path for building “One Missouri”—one that benefits rural and urban areas alike, takes full advantage of current state investments in higher education to maximize their return in terms of wealth and jobs, and builds on a traditional bio-processing base around newer life science breakthroughs to help establish, expand, and attract the industries of the future for Missouri.

Missouri is at a crossroads. The state can lead or be left behind. The actions proposed in this strategy, if implemented, will propel Missouri forward in a race that Missouri cannot afford to lose.

Introduction

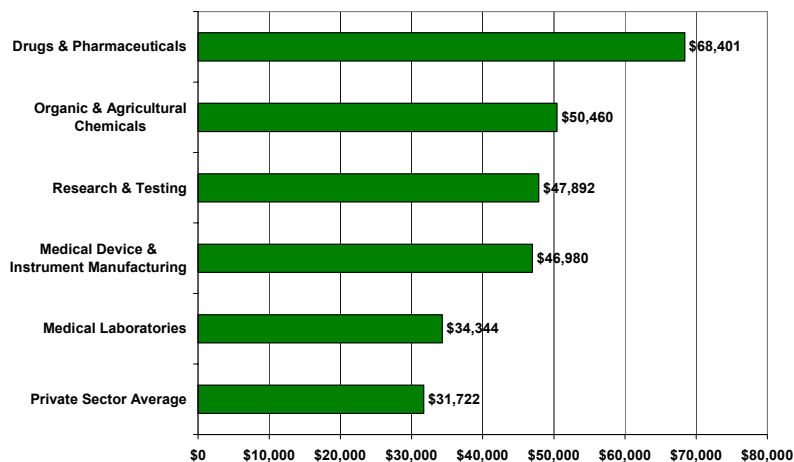
Missouri is in the midst of an economic race for the future. Stiff foreign competition continues to cut at the edges of the state’s traditional economic strengths in manufacturing, requiring firms to push toward more modernization and higher productivity, resulting in reduced jobs with greater output—just to stay in place. At the same time, industries of the future are emerging based on the technological advantages found across the United States, where states can generate high-quality jobs in growing industries.

The life sciences are a major cluster of industries in which the technological superiority of the United States can sustain economic advantage and growth for years to come. The life sciences are not only about research, though advances in new fields of genetics, proteomics, tissue engineering, and computational biology are opening up exciting, new economic opportunities. The growth of the life sciences is also driven by the aging of the population, generating significant markets for new disease treatments and advanced medical services, as well as by continued population growth and the need to advance improved, high-yield food production.

Many industries are involved in the life sciences—drugs, medical devices, health services, research and testing, agriculture-related industries, and other key supplier and component manufacturing industries. Similarly, employment opportunities in the life sciences go well beyond just those for well-educated scientists and medical

doctors. The highest share of employment in the life science industries is in production and technician positions, reaching more than 50 percent of employment in medical devices, 40 percent in the pharmaceutical industry, and more than 30 percent in agricultural chemicals. Even with this mix of industries and occupations, average earnings per worker in the life sciences stands well above the national average (Figure 1).

Figure 1: Average Earnings by Industry, U.S., 1998



Source: U.S. Department of Commerce.

It is no wonder then that more than 40 other states are looking at ways to enhance their life science base. It is not just blockbuster, highly publicized new drug companies that generate wins, but a broad range of activities.

Missouri is in the running for a strong position in the life sciences. But the state’s life science base today faces a fundamental juncture between two possible futures. It is neither a clear leader nor a straggler in today’s life science world. Missouri possesses strengths in agriculture, bio-processing, food and nutrition, health care, and animal and plant sciences. Its research base is also growing, from which further technology commercialization in the life sciences can occur. Missouri has not one but two new world-class, nonprofit life science research institutes, the

Stowers Institute for Medical Research in Kansas City and the Donald Danforth Plant Science Center in St. Louis. At the same time, Washington University’s continued growth as a major international university in the plant and life sciences and recent state investments in the University of Missouri system and its campuses also show a state on the move. Yet, declining employment in the nonclinical biomedical life sciences and only modest growth in high-technology life science research and testing industries are a cause for concern in positioning the state as a life science leader.

Immediate and sustained action to strengthen Missouri’s position in the life sciences is critical. The state has the opportunity, by building upon its historical strengths as well as recently enhanced interest and investments, to develop into a prominent life science center. The actions and efforts undertaken during the next decade likely will be decisive in determining Missouri’s future position in the life sciences.

Currently, Missouri faces difficult short-term budgetary challenges because of problems with the national and state economies; however, now is not the time to disinvest in those sectors of the economy that will help to build a stronger Missouri for the future. Notwithstanding the short-term fiscal challenges, Missouri must continue to build a solid foundation that will guarantee the state a stronger economy in the future—one that will endure in good times and bad.

The life sciences have already begun to serve as a unifying force among rural parts of Missouri and the two major metropolitan areas—St. Louis and Kansas City—which have both made this a key strategic focus for their regional future and are working jointly to build this sector for the state. In other words, the life sciences are a cornerstone for **“One Missouri,”** one vision around which to build a healthy and safe citizenry, as well as a strong, competitive economy.

Accordingly, in 2001 the State of Missouri, the University of Missouri System, the Danforth Foundation, and the Ewing Marion Kauffman Foundation initiated the development of this Life Science Strategy to guide future public and private investment decisions in Missouri. A Steering Committee was established to oversee this effort, and Battelle Memorial Institute’s Technology Partnership Practice (TPP) was engaged to in developing the strategy.

Battelle is recognized worldwide for technology development, management, and commercialization, as well as for the development of industry, academic, and government partnerships. Founded in 1929 by Gordon Battelle and his family, Battelle has been a worldwide leader in the development, commercialization, and transfer of technology for industrial and governmental organizations for more than three generations. Battelle’s TPP, which includes leading analysts

Examples of Other States’ Investments in the Life Sciences

- Michigan is investing \$50 million/year for 20 years in the Life Sciences Corridor.
- Ohio is investing \$20 million to \$25 million/year in its Biomedical Research and Technology Transfer Fund.
- Pennsylvania is providing \$60 million annually for basic research; over \$160 million in one-time funds for bioscience-related venture funds; and is establishing three Life Sciences Greenhouses.
- California is investing \$100 million in a bio-engineering and biotechnology institute, and \$500 million in pension funds towards the California Biotechnology Program.
- Texas appropriated \$800 million for seven new or expanded health science research centers.
- Wisconsin launched BioStar, a \$317 million, 10-year research initiative, and the Wisconsin Investment Board, the state’s pension fund, has invested \$50 million in two venture funds for investment in life science companies.

and practitioners in technology-based economic development, helps clients develop, implement, and evaluate technology strategies, policies, and programs.

This strategy was developed with input from Missouri’s universities, nonprofit research institutions, life science companies, and other public and private leaders throughout the state.

The Battelle project team collected and analyzed data on Missouri’s research and industry base; assessed Missouri’s competitive position vis-à-vis a number of competitor and peer states; and interviewed academic, research institution, and business and civic leaders to develop an understanding of Missouri’s existing life science research strengths and capabilities and to gather input on the types of activities needed to position Missouri to become a leader in the life sciences.

This report includes

- An assessment of Missouri’s life science research base that examines trends in life science funding flowing to Missouri’s research institutions
- An economic analysis of the current strengths, dynamics, and changes in the state’s life science industry base
- An assessment of Missouri’s competitive position vis-à-vis other states that have or are trying to develop their life science sectors on the key factors needed to support the development of the life sciences
- Identification of the core competencies of Missouri’s research institutions
- A situational analysis that reports findings based on interviews with many of the state’s public and private sector leaders in regard to strengths, weaknesses, opportunities, and threats (SWOT) facing Missouri in its effort to position itself in the life sciences
- Proposed strategies and actions to position Missouri to become a leader in the life sciences
- An implementation plan that outlines initial steps for executing the strategies and actions.

Life Science Strategy Methodology

- Economic analysis
- Core competency analysis
- Benchmarking analysis
- SWOT review
- Interviews of academic, business, and community leaders
- Focus groups and discussions
- Economic impact analysis

Missouri's Life Science Base

In considering the base of life science activity, two dimensions are critical—the life science research base and industry development. The life science sector stands out from other technology sectors due to its close relationship between basic research discoveries and product development. Major new products and innovations in the life sciences are frequently related to basic research discoveries; whereas, in other technology sectors, the links are less direct. Given the importance of research to life science product development, it is not surprising that a common feature of states and regions with vibrant, growing life science sectors is the presence of major universities and nonprofit research institutions.

From the perspective of industry development, the life science base is wide ranging, involving manufacturing, agriculture, services, and research activities. The life sciences are also becoming a focal point for the convergence of technologies with advanced manufacturing essential to develop innovative products such as artificial organs and noninvasive surgery techniques and with information technology critical for mining the wealth of genomic data being generated for drug discovery and diagnosis.

MISSOURI'S LIFE SCIENCE RESEARCH ENTERPRISE

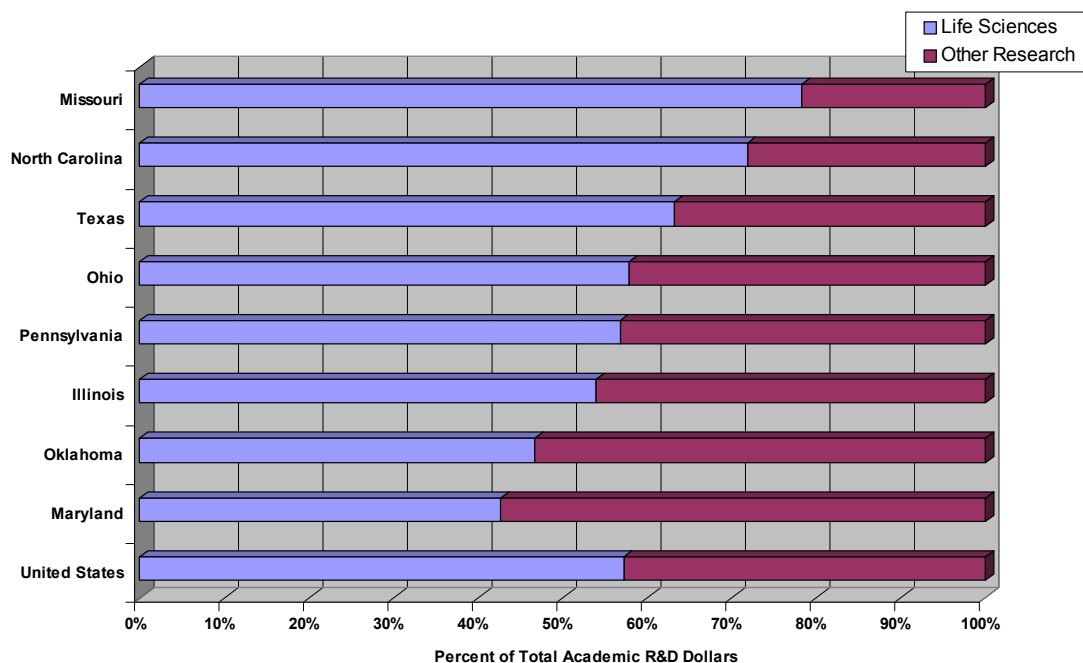
Major university and nonprofit research institutions not only are the key to basic research discoveries that generate product leads for life science companies but, more importantly, create an environment in which life science companies can flourish. Moreover, these institutions can be an asset for the life science industry in bridging the gap between basic and applied research.

Key trends in life science research, particularly focused on university research activity, are examined in the following paragraphs.

The life sciences dominate university research efforts in Missouri. Roughly \$8 out of every \$10 in university research expenditures is spent on life science research, according to data from the National Science Foundation (NSF). This places Missouri second in the nation in the concentration of life science research. Nationally, less than \$6 out of every \$10 is spent on life science research (Figure 2).

Despite this strong concentration of its research efforts in the life sciences, **Missouri currently stands in the second tier of states in overall university life science research.** In university research expenditures from all sources, according to NSF data, Missouri ranks 12th in overall life science research funding, 8th in biological sciences, 14th in medical sciences, and 16th in agricultural sciences. In related fields, it ranks 16th in bioengineering, 19th in chemistry, 22nd in psychology, 29th in chemical engineering, and 41st in environmental sciences (Figure 3).

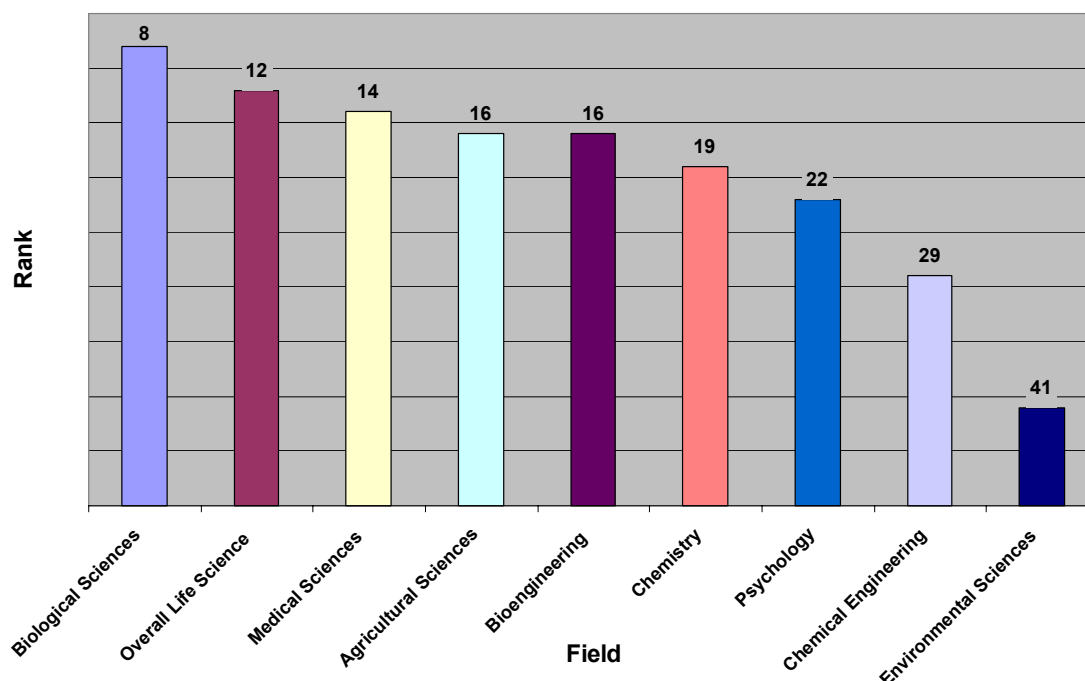
Figure 2: Academic R&D Dollars in the Life Sciences Compared with Total Academic R&D, FY 1999



Source: National Science Foundation.

Note: Southern Illinois University is included within the State of Illinois, although the university is located within the St. Louis metropolitan area; Southern Illinois University reported only \$610,000 in bioscience R&D from 1995-1999. The Missouri data does not include Kansas City, Kansas, because NSF data are not reported separately for the University of Kansas Medical Center.

Figure 3: Missouri National Rankings in Life Science Fields



Source: National Science Foundation.

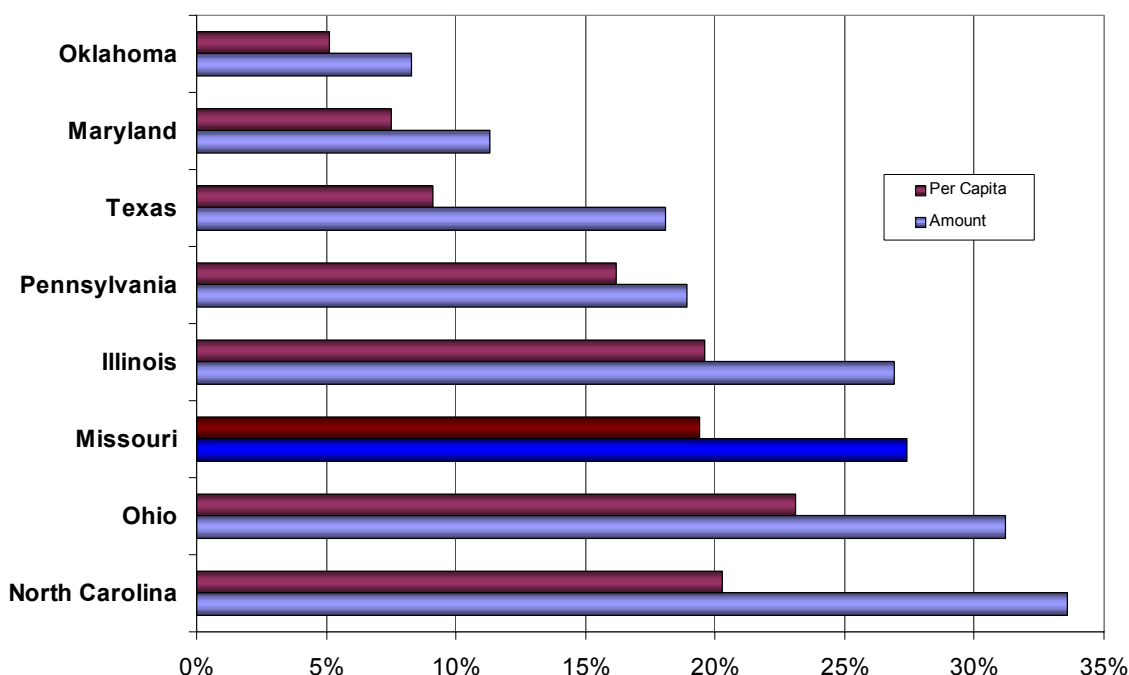
Note: Southern Illinois University is included within the State of Illinois, although the university is located within the St. Louis metropolitan area; Southern Illinois University reported only \$610,000 in bioscience R&D from 1995-1999. The Missouri data does not include Kansas City, Kansas, because NSF data are not reported separately for the University of Kansas Medical Center.

Missouri does possess one world-class life science research university among its research drivers—Washington University. Washington University ranks 5th in National Institutes of Health (NIH) research funding—the “gold” standard of biomedical research funding.

Life science research in Missouri has been growing at a rapid pace over the past five years, and with continued support, Missouri is on the verge of making the leap into the first tier of states in life science research. Overall life science research growth in Missouri is outpacing the nation and many leading states (Figure 4 and also Table 4 in the *Missouri Benchmarking Analysis*). Universities across Missouri are placing a major emphasis on life science research. All of the main campuses of the University of Missouri are actively investing in the growth of their life science research efforts. In addition, the University of Kansas and Saint Louis University also are firmly committed and focused to growing their life science research base. In addition, life science research in Missouri in the years ahead will greatly benefit from the recent formation of two major nonprofit research institutions that are destined to join the ranks of world-class, nonprofit life science research institutes—the Donald Danforth Plant Science Center and The Stowers Institute for Medical Research. It is expected that these two institutions together will add in excess of \$100 million in annual life science research to Missouri.

Along with the growth in basic research, **Missouri continues to advance its position in clinical and applied research**, which is the foundation for translating basic research discoveries into new medical treatments, agricultural products, and environmental services and products.

Figure 4: Percent Change in Life Science Academic R&D, FY 1995-1999



Source: National Science Foundation.

Note: Southern Illinois University is included within the State of Illinois, although the university is located within the St. Louis metropolitan area; Southern Illinois University reported only \$610,000 in bioscience R&D from 1995-1999. The Missouri data does not include Kansas City, Kansas, because NSF data are not reported separately for the University of Kansas Medical Center.

Examples of Clinical and Applied Research Efforts in Missouri

- Kansas City through its extensive network of hospitals is a leading center for clinical research, especially in cardiovascular, stroke, and pediatric diseases. Midwest Research Institute is also a key center for applied research and development, involving testing and prototype development, with growing partnerships with local research institutions.
- Washington University has strong clinical research strengths, having an NIH-funded General Clinical Research Center to facilitate and support patient-oriented research, along with a Center for Clinical Studies to support the evaluation of new pharmaceuticals and medical devices.
- Saint Louis University brings a strong focus on clinical research, especially in the area of vaccine evaluations.
- The University of Missouri with its extensive farm system, along with other experimental agricultural facilities found at nonresearch universities in Missouri, offers a tremendous test-bed facility for new advances in plant science.
- Fort Leonard Wood is a major testing center for new environmental technologies.

Missouri faces significant challenges in the growing importance of technology convergence in life sciences with other technology fields, particularly information technology and engineering.

Missouri, reflecting its high concentration in life science research, lags behind leading states in the level of research funding in engineering and computer science research funding. To illustrate this point further, among the top 10 states in life science research, Missouri lags far behind in engineering and computer science research. In addition, the research that Missouri is conducting in these fields tends to be more niche oriented because of its smaller size.

Ernst & Young in 2000 annual report on the biotechnology industry explains this convergence:

“From agriculture to fine chemicals, from drug discovery to health, companies are migrating and integrating their scientific approaches and business aspirations to create broad platforms for new products and markets. Fueled by—and contributing to—developments in information technology and nanotechnology, these hybrid markets are true bellwethers of the information age, generating enormous quantities of information at multiple scales of time and space.”

MISSOURI’S LIFE SCIENCE INDUSTRY

The economic analysis of the Missouri life sciences presents a mixed picture. On the one hand, Missouri has a sizable and growing base in the life sciences. On the other hand, this growth is being driven primarily by expansion of the hospital and laboratory subsector. If hospitals and laboratories are excluded, Missouri’s life science sector has shown a decline in employment. In addition, the lack of dynamism in the high-technology research and testing and drug/pharmaceutical subsectors, the core of what is popularly thought of as biotechnology, does not bode well for future growth of the life sciences.

Brian Sager, Ernst & Young Life Sciences Strategy Consultant, “Strategic Drivers of Convergence,” *Convergence: The Biotechnology Industry Report, Millennium Edition*, 2001, page 26.

The following section presents the key findings of an economic analysis of recent trends in Missouri’s life science sector. For this analysis, the term “life sciences” is used to refer to a relatively broad range of biological and life-science-related activity: food and nutrition, organic and agricultural chemicals, drugs and pharmaceuticals, medical devices and instruments, hospitals and laboratories, and life science research and testing. This definition encompasses the core industries upon which Missouri can build its future in the life sciences.¹

Missouri has a sizable base in the life sciences. Missouri’s life science sector consists of 1,815 establishments employing more than 193,000 workers. Overall, private sector life science employment stands 14 percent above the concentration found nationally. More impressively, growth in the Missouri life science sector was 11 percent, compared with 7.3 percent nationally. These overall figures, however, mask some key trends and developments.

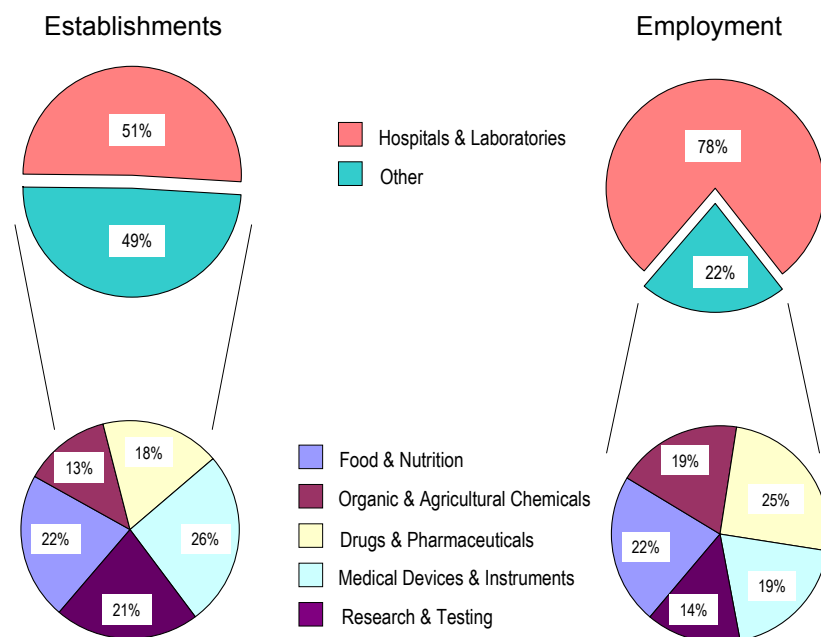
Missouri’s Life Science Profile

- 193,117 employees
- 11 percent employment gain, '95-'01
- 34.8 percent establishment increase, '95-'01
- Location quotient 1.14

The growth of Missouri’s life science sector is being driven by the state’s large and growing hospital and medical laboratory subsector. Hospitals and laboratories are the largest life science subsector in Missouri (Figure 5), as is true across the nation. Missouri differs from the

¹ Throughout the economic analysis, the State of Missouri typically is considered together with the out-of-state portions of the St. Louis and Kansas City metropolitan regions; the amalgamated region is referred to simply as “Missouri.”

Figure 5: Life Science Subsectors, Missouri, 2001



nation in that the hospital and laboratory subsector gained 17.5 percent in employment in the last six years, while the same industries advanced by only 3.8 percent nationwide. Currently, Missouri has a 20 percent higher concentration of hospital and laboratory activity than is found nationally. For the most part, hospitals and medical laboratories are a basic service found in nearly all communities. However, those hospitals involved with research activities as part of an integrated academic medical center can be part of a broader economic driver, where leading medical care serves to attract patients and medical research funding from outside the region and supports the commercialization of new medical treatments. In Missouri, Barnes Jewish Hospital, Children’s Mercy Hospital, and St. Luke’s Hospital are examples of hospitals that are important research drivers. Unfortunately, relatively few hospital and laboratory establishments nationwide are significantly engaged in research, and the Missouri-specific data concerning hospitals and medical laboratories cannot be disaggregated to distinguish community hospitals from those with significant research enterprises.

When hospitals and laboratories are excluded, the Missouri life science sector has performed below the national level in recent years. Missouri’s life science sector, excluding hospitals and laboratories, consists of 889 establishments and more than 41,000 life science workers. Between 1995 and 2000, the Missouri life science sector decreased its employment level by 7.6 percent compared with a national growth rate of 18.8 percent. This was slightly less than Missouri’s overall decline in total manufacturing employment of 9.2 percent. Missouri places slightly behind the national concentration of nonhospital life science employment, being 95 percent as concentrated as the nation.

Missouri’s Life Science Profile excluding Hospitals (2001)

- 889 establishments
- 41,635 employees
- 7.6 percent employment decline, '95-'01
- 29.2 percent establishment increase, '95-'01
- Location quotient 0.95
- 1.2 percent of private sector employment

Missouri’s largest strengths in the life sciences are found in bioprocessing manufacturing: food and nutrition is a specialization, while the closely related organic and agricultural chemical subsector is also more concentrated than the nation, though not yet a regional specialization. With nearly double the national employment concentration, the food and nutrition subsector is the strongest Missouri life science specialization and employs more than 9,300 workers across just under 200 establishments. Its employment has only held steady since 1995, however. Key growth industries include cheese production and ice cream and frozen desserts. The related organic and agricultural chemical subsector stands 11 percent more concentrated in Missouri than across the nation, falling just short of being a regional specialization, with 7,900 workers across 116 establishments. A primary industry strength is found in agricultural chemicals with a concentration nearly three times the national average—this industry employs 3,200 workers, more than double its Missouri employment level just six years ago.

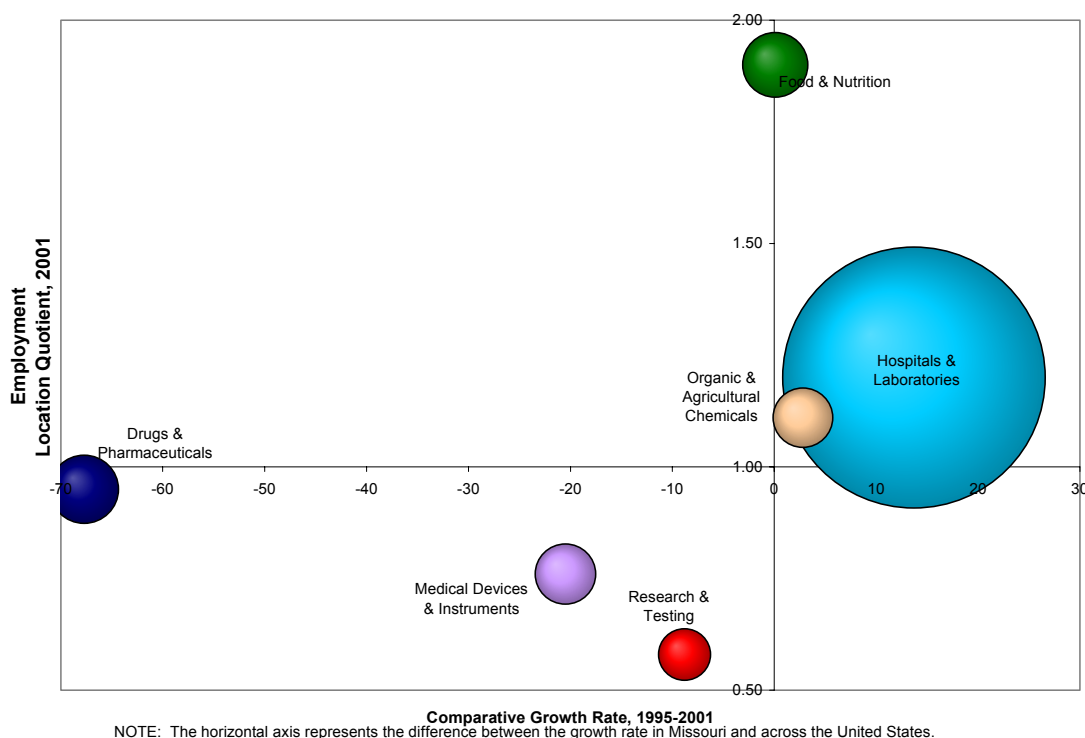
Pharmaceuticals—a traditional specialization in Missouri—has been hit hard with declines in employment across the state, even as it has recorded strong growth nationally. One promising sign has been strong growth in establishments in Missouri. Drugs and pharmaceuticals, a traditional strength within Missouri, declined in employment by 28.7 percent between 1995 and 2001, while growing nationally by 39 percent. This subsector has undergone considerable upheaval with numerous consolidations and mergers in recent years. Despite the decline in employment, the number of pharmaceutical establishments in Missouri continues to rise, increasing 31 percent since 1995, demonstrating the subsector’s continued presence in Missouri and potential base for future growth. However, it will require substantial effort and time to rebuild this subsector’s strength.

Medical devices and instruments—a smaller subsector in Missouri—also fell well behind national employment growth rates. Medical devices and instruments in Missouri, while already less concentrated than across the nation, recorded an employment decline of 7.4 percent, compared with a national growth rate of 13.1 percent over the past six years.

The research and testing subsector—a key life science subsector reflecting emerging and innovative biotechnology companies—did not keep pace with national growth rates. Thus, despite gains in employment and establishments, Missouri continues to lose ground to the nation in this key subsector. While Missouri experienced employment growth of 27 percent and rapid establishment creation in research and testing (66 percent growth), the state still fell slightly below the national growth rates both in terms of employment (36 percent) and establishment gains (74 percent). So, despite healthy growth in Missouri, this most dynamic of the life science subsectors at the national level does not constitute a growing specialization in Missouri and currently stands at only 60 percent of the national level of concentration.

As a further illustration of the overall trends in the life science sectors, Figure 6 depicts the six Missouri life science sectors classified by employment size, comparative growth rate, and relative concentration. The area of each disk corresponds to the amount of employment in that sector. Although most of the sectors are near the national level of concentration, food and nutrition is almost double; whereas life science research and testing is only slightly above half. Both organic and agricultural chemicals and hospitals and laboratories are growing more rapidly within Missouri than across the nation, but medical devices and instruments, research and testing, and especially drugs and pharmaceuticals are behind the national pace of growth. Hospitals and laboratories is a large enough subsector that it largely drives the entire Missouri

Figure 6: Missouri’s Six Life Science Subsectors by Employment Size, Comparative Growth Rate, and Relative Concentration



life science sector. Perhaps most importantly, the three subsectors in the bottom left quadrant of the figure, with lower than average concentrations and negative comparative growth rates, are usually considered to be the higher technology and more economically influential life science subsectors. Food and nutrition in particular is less technology-based than the other life science subsectors, while the hospital and laboratory industries do not tend to be influential economic drivers or generate substantial life science employment outside of the subsector.

Missouri’s future requires it to move more of its industries toward the upper right quadrant if it is to be a major player in the life sciences. **The subsectors currently demonstrating strength within the Missouri life science sector are those that tend to be less technology-intensive and have less economic impact potential.**

Life science establishments and employment are found across the state, with some sectors more concentrated in metropolitan St. Louis and Kansas City.

Primarily, food and nutrition and hospitals and laboratories are spread throughout Missouri; the other life science subsectors are concentrated in the major metropolitan areas. However, there is a cluster of

Key Points – Life Science Spatial Distribution

- Approximately two thirds of life science establishments and employment are located in metropolitan St. Louis and Kansas City.
- Food and nutrition and hospitals and laboratories are spread throughout Missouri; the other four sectors are mainly concentrated in the major metropolitan areas.
- There is a veterinary science cluster in St. Joseph; a food and nutrition cluster in Springfield and Joplin; and a research and testing cluster in Columbia.

veterinary science activity in St. Joseph, food and nutrition in Springfield and Joplin, and research and testing in Columbia. Within the St. Louis and Kansas City metropolitan regions, major life science employers tend to be situated in middle-ring suburbs and not clustered. The absence of close spatial clustering may make it more difficult to target support services or to engage in collaborative efforts to support the life sciences in Missouri.

While the Missouri research and testing subsector has demonstrated an active entrepreneurial culture, it has enjoyed relatively little success in generating new employment at the local and regional levels. More than 30 percent of research and testing establishments in Missouri are five years old or less, but they employ less than 11 percent of the subsector’s workforce, a fraction only half the national level. In addition, 67 percent of the employment in the subsector is contained within branch sites, the type of establishment that exerts the least local control.

This assessment of Missouri’s life science industry base suggests that, **to grow the state’s life science sector, Missouri must**

- Keep and grow its industry base in its traditional manufacturing subsectors, including food and nutrition, organic and agricultural chemicals, and medical devices and instruments. If the consolidation and downsizing that have led to decreases in employment can be slowed, these subsectors can provide a solid foundation upon which the entire life science sector can continue to build and advance.
- Seek to encourage the growth of the state’s research and testing and drugs and pharmaceuticals industries by encouraging new firm creation and supporting the growth of young entrepreneurial companies.
- Create an environment that will attract life science companies to locate and expand operations in Missouri.

Core Focus Areas on which to Build Missouri’s Life Science Base

The life sciences present a broad set of opportunities for development. It is critical, therefore, to ascertain whether Missouri is positioned through its university and nonprofit research drivers in specific areas of life science research. In other words, it is important to identify the areas of core research strength among the research drivers in Missouri as a key building block for a comprehensive, integrated life science strategy.

AREAS OF CORE RESEARCH STRENGTH IN MISSOURI

Missouri has a wide range of specific strengths in the life sciences reflecting its diverse set of research drivers. This section examines those areas of focus, based on interviews with key faculty and administrators and review of secondary data sources, to give a more specific description of the character of the life sciences across the state (see Appendix A for details of this assessment). It is important to understand these core focus areas since they can help identify the possible paths for a comprehensive, integrated development strategy for Missouri in the life sciences.

One important caveat: these core areas of strength relate to a critical mass of research activities identified by the Battelle team. Other fields of life science research excellence may be present in Missouri. However, these other life science strengths are found in relatively limited pockets and so offer limited opportunities to build upon.

The specific strengths are best understood as falling within three broad areas of life science research, namely

- **Plant and agriculture-related sciences** with major strength in plant science focusing on crop improvements, improved human health, and industrial uses of crops, along with a focused strength in animal sciences.
- **Human disease treatment** involving specific disease areas of neurological and psychiatric disorders, cardiovascular diseases, infectious diseases, reproduction, cancer, and geriatrics.
- A third, less-developed and potential emerging area is **environmental technologies**, with a concentration in the Rolla/Ft. Leonard Wood region involving environmental protection as well as homeland security. Saint Louis University, with its Center for the Study of Bio-terrorism and Emerging Infections, and Midwest Research Institute (MRI) also are positioned to play a national role in biological and chemical defense.

Battelle Core Competency Methodology

To carry out this assessment of core research focus areas, the Battelle team:

- Conducted interviews with key research administrators and faculty to obtain their views on current and future respective strengths.
- Reviewed secondary data sources and studies.

Underpinning the broad areas of bioscience² research are more basic research efforts that typically cut across these areas and serve as tools for developing bioscience applications to address agricultural sciences, human diseases, and environmental technologies. These basic

² The terms “bioscience(s)” and “life science(s)” are used interchangeably in this report.

research areas of specific expertise are considered tools, and these tool areas are not only enablers but also offer their own opportunities for research, testing, and development companies. In Missouri, a number of specific existing and emerging areas of strength in life science research tools are cross-cutting (Figure 7):

- **Genomics, Proteomics, and Bioinformatics** encompassing a wide range of efforts from genome sequencing to functional genomics using model organisms to innovative techniques for modeling and forecasting of the structure of proteins
- **Drug Design and Development** led by key strengths in pharmacology and pharmaceutical sciences
- **Bioengineering** with strong emphasis on imaging, biomaterials, and computational methods.

Figure 7: Depiction of Missouri University Research Core Focus Areas

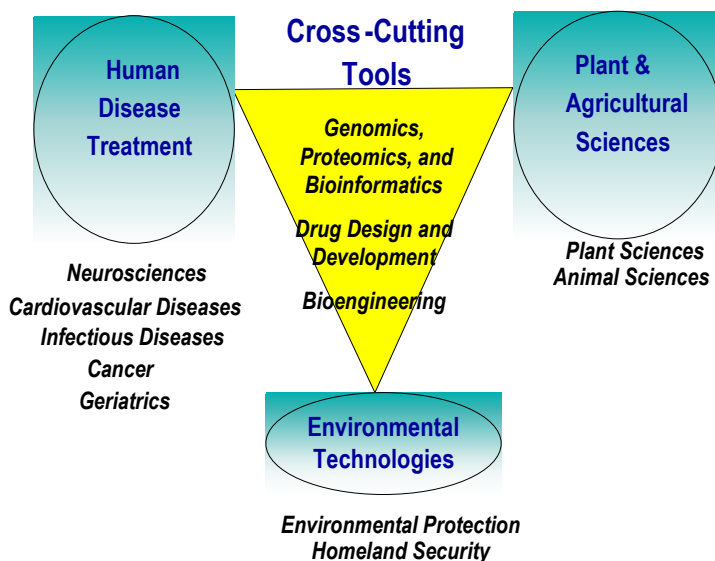


Table 1 provides a summary of these areas of core research strength, identifying examples of applications in Missouri, key strengths drawn upon, and leading research institutions involved in each area.

Table 1: Summary of Areas of Core Competency

Area of Core Focus	Example of Applications	Key Strengths to Draw Upon	Leading Research Institutions Involved
Cross-Cutting Tools			
Genomics, Proteomics, and Bioinformatics	Ability to identify specific genetic mechanisms involved in human diseases and plant development	Molecular genetics Genome sequencing Structural biology Computational biology	Washington University UM-Kansas City Stowers Institute for Medical Research Danforth Center
Drug Design and Development	Improved drug solubility, stability and tissue targeting Pediatric drug treatments Drug design	Pharmaceutical chemistry Pharmacology	University of Kansas Washington University UM-Kansas City UM-Columbia Children’s Mercy MRI
Bioengineering	Imaging, Adhesive dental composites, Bone repair and substitutes, Delivery of drugs and therapies	Tissue engineering Bone biology Material sciences Computational biology	Washington Univ., UM – Rolla, UM – Kansas City, MRI
Plant and Agriculture-Related Sciences			
Plant Sciences	Improved crop yields, resistance to disease and pests, and plant nutrition Unique focus on tropical (RH1) botany Improved human health through nutraceuticals, development of vaccines delivered in food, use of tropical plants for unique anti-cancer and anti-AIDS compounds, healthier meats, and research programs on herbal dietary supplements Industrial uses of plants including use of soybeans to create composites, oils, coatings, etc.	Genomics Proteomics Cell and development biology	UM-Columbia Donald Danforth Plant Science Center Washington University UM-Rolla Missouri Botanical Garden UM-St. Louis MRI
Animal Sciences	Animal nutrition, animal vaccines, productivity	Immunology Genomics Proteomics	UM-Columbia MRI

Table 1: Summary of Areas of Core Competency (continued)

Area of Core Focus	Example of Applications	Key Strengths to Draw Upon	Leading Research Institutions Involved
Human Disease Treatment			
Neurological and Psychiatric Disorders and Injuries	Alzheimer’s disease Multiple sclerosis Nerve growth factors Brain and spinal injuries Epilepsy Stroke Parkinson’s disease	Neurology and neurobiology Imaging Cell biology Pharmacology Stem cell research	Washington University University of Kansas
Cardiovascular Diseases	Heart disease Hypertension Cystic fibrosis Renal failure	Cardiology Heart surgery Molecular biology Physiology	UM-Columbia Washington University Mid America Heart Institute in Kansas City
Infectious Diseases	HIV, hepatitis, yellow fever, herpes	Microbiology Immunology Virology Proteomics	Saint Louis University Washington University
Cancer Research	Bone marrow transplantation Radiopharmaceuticals Multiple cancer diseases	Human genetics Proteomics Cell biology Immunology Nuclear medicine Pharmacology	Washington University UM-Columbia University of Kansas Stowers Institute for Medical Research
Geriatric Research	Osteoporosis, arthritis, hypertension, prostate disease	Human genetics Immunology Proteomics Endocrinology	UM-Columbia University of Kansas Washington University
Environmental Technologies			
Environmental Protection	Bioremediation Ecological sustainability Biosensors Environmental controls Biological nutrient removal processes Integrated chemical/biological processes for water treatment	Environmental engineering Informatics Molecular biology	UM-Rolla UM-St. Louis Washington University MRI
Homeland Security	Chemical, biological, and radiological detection Hazard marking Natural disaster recovery Demining Modeling, simulations and analysis Training	Bioengineering	Ft. Leonard Wood UM-Rolla Saint Louis University MRI

STRATEGIC ASSESSMENT OF MISSOURI’S CORE RESEARCH STRENGTHS

The strategic assessment of Missouri’s core research strengths addresses two issues:

- What are the development implications of these core research areas based on industry linkages present in Missouri and external market factors?
- What are the key policy issues that Missouri needs to address to leverage its core research strengths?

Development Implications of Core Research Areas

Taking into consideration a number of key factors involving industry linkages in Missouri and external market factors sheds light on the development potential for each of the broad areas.

Cross-Cutting Tool Areas

External Market Factors: One key factor is the strong drive toward outsourcing drug discovery and development services. New development tools and services, especially innovations in genomics, proteomics, and bioinformatics, are another key market opportunity. Bioengineering opens up significant new market opportunities across a broad range of advanced medical products, from improved diagnostics to tissue engineering, with opportunity for new start-ups in niche areas.

Linkages with Industry: Missouri has a significant presence of contract research and biological supply companies, led by Sigma-Aldrich, Quintiles, Midwest Research Institute, Pharmaceutical Research Associates, and ABC Laboratories. A group of new start-ups is also growing in this area, such as ProQuest, Critech, BioScience Innovations, CyDex, Oread, and XenoTech. Moreover, the presence of bioinformatics companies in the state is growing, including firms such as Tripos, Incyte Genomics, Cerner Corporation, Express Scripts, and Orion Genomics.

Key Challenges: Across the areas of genomics, proteomics, bioinformatics, and drug design and development, there are significant market opportunities, largely to be captured by new start-up companies. However, Missouri has not been a leader in the dynamic research and testing subsector, which forms the cornerstone of companies developing and using these cross-cutting life science tools.

Plant and Agriculture-Related Sciences

External Market Factors: Significant growth potential exists across a wide number of market segments. In the plant sciences, initial development has focused on input traits for pest and insecticide resistance. The next wave is expected to be in more output traits, such as grains with improved nutritional content, fruits that carry vaccines, and cotton with enhanced durability. Considerable opportunities also exist in food safety diagnostics. In the animal sciences, new products to treat animals continue to be introduced, demonstrating the growth potential of this industry, with a wide variety of market segments, including recombinant growth hormones, endectocides to kill parasites, diagnostic reagents and tests, biologicals from vaccines to anti-toxins to bactericins, feed enzymes, and therapeutics and flea/tick controls for companion animals.

However, both the plant sciences and animal sciences face significant market challenges. For the plant sciences, continued public resistance to genetically engineered foods and the prospect of heavy-handed regulation may slow down growth of the sector. For the animal sciences, major concern remains with bovine spongiform encephalopathy (BSE or mad cow disease), which can have a major impact on reducing meat consumption.

Linkages with industry: In Missouri, there are strong industry linkages in the plant and agriculture-related sciences which relate strongly to two subsectors of the life sciences—food and nutrition and organic and agricultural chemicals—as well as the overall agriculture/farming industries. Missouri has leading firms in the food, nutrition, and ag chemicals subsectors, including Purina Mills, Kraft, Conopco, Dairy Farmers of America, Archer Daniels, Midland, Protein Technologies, Monsanto, Chemsico, and Bayer. These leading firms provide excellent opportunities for partnering and accessing markets and also are key research generators on their own account. A less-recognized strength in Missouri are the animal sciences, with a particular concentration found in the St. Joseph area. Leading firms found in St. Joseph include: Boehringer Ingelheim Vetmedica, Phoenix Scientific, Friskies PetCare and Friskies PTC, Omnium LLC, Research Seeds Inc., and Urbana Laboratories. But, the animal sciences also reach across the state with a wide range of companies, including Bayer Agriculture Division—a leader in animal vaccines—with 1,500 employees in the Kansas City region and Fort Dodge Animal Health, a division of American Home Products, headquartered in Overland, Kansas. Many smaller animal sciences companies also are found in Missouri.

Key Challenges: Overall, the prospects in Missouri for plant and agriculture-related sciences appear very bright. One key initiative is to achieve for animal sciences the same level of linkage between research and industry development that is found in the plant sciences.

Human Disease Treatment

External Market Factors: Health care is a major sector of our economy, comprising more than 13 percent of our nation’s gross domestic product. Beyond direct clinical care, the key industries composing the health care marketplace include drugs and pharmaceuticals, medical laboratories, bioscience research and testing, and medical devices and instruments and represent more than \$500 billion in worldwide sales. Some overall factors driving human disease treatment include favorable demographic trends with the aging of the population, strict regulations that are keeping development costs high, and reimbursement issues that are critical for advancing the market acceptance for new innovations.

The specific fields in which Missouri enjoys a critical mass of core research strength relate to the key diseases found in the United States—neurological/psychiatric, cardiovascular, infectious diseases, and cancer. Geriatric care cuts across many of these disease areas and relates to the aging of the population. Neurological treatments face the challenge of addressing the complexity of the brain, but the market opportunities for even incremental improvements of lower side effects and some disease reversal are substantial. Cardiovascular treatments offer major opportunities both in new drug and medical device focus areas. Cancer treatments are the leading area of new drug development efforts for pharmaceuticals. Infectious diseases, while a major cause of death, have significant product liability issues associated with vaccines. The market value associated with the use of vaccines and antibiotics is much lower than that of other drugs that need to be taken more regularly.

Linkages with Industry: Industry sectors associated with human disease treatment—pharmaceuticals and medical devices—have been hit hard in Missouri, while growing nationally. Missouri has a legacy of pharmaceutical industry presence in the state; but this industry has been a victim of consolidation, with employment down by 28.7 percent from 1995 to 2001, while nationally it was growing by more than 39 percent. The medical device industry has not traditionally had a strong presence in Missouri, despite the state’s manufacturing heritage. Employment has been declining in Missouri while increasing nationally.

One concern is that many of the remaining efforts of major pharmaceutical companies in Missouri are more focused on drug preparation and production than on drug discovery. For instance, Bayer Pharmaceutical Division’s and Aventis Pharmaceuticals’ primary efforts in Missouri are producing active ingredients for their drugs. However, the possibility for more drug discovery is apparent in the focused efforts of Pharmacia’s new involvement in Missouri through acquiring Monsanto, including its world-class life science research facility in Chesterfield, which is now emerging as a major component of Pharmacia’s biotechnology pharmaceutical discovery efforts.

Key Challenges: For Missouri, the key to future development of industry linkages in human disease treatments will be the start-up of new companies. Missouri also needs to continue to identify ways to leverage and strengthen the presence of major pharmaceutical companies.

The areas of core research focus in Missouri, while offering significant market opportunities, are also highly competitive. Missouri will need to run hard just to keep up with other efforts across the nation in areas such as neurological disorders, cardiovascular diseases, and cancer. To be a leader will require not only basic research strength but also the abilities to bring multidisciplinary approaches forward and to conduct translational research.

Environmental Technologies

External Market Factors: Overall, this is a \$203 billion dollar industry in the United States. The latest figures show a 2.7 percent annual growth rate (1997) across four traditional markets of water supply and treatment (5 percent), solid waste management (3 percent), air pollution control (3 percent), and environmental cleanup (2 percent). All of these traditional environmental markets are subject to being mature markets, with intense competition, slim profit margins, and slow demand drivers. Key new trends include pollution prevention, with ecoefficient or green technologies, and major advances in monitoring techniques and assessment techniques, with the emerging process and prevention technology segment estimated to be advancing at 7 percent annually.

A major new market opportunity is homeland security involving addressing bioterrorism and environmental monitoring/security technologies in light of events surrounding September 11th. The full scale of these opportunities is still emerging, but is expected to be in the billions of dollars from both federal, state and local governments as well as private organizations.

Linkages with Industry: A key driver for Missouri is the presence of Fort Leonard Wood and its range of activities involving environmental technologies, and increasingly, homeland security, which often involves attracting industry to the state to provide contract services. Beyond Fort Leonard Wood, the state has a broad range of companies, typically smaller in size but bringing strengths in new product development. For example, Brewer Sciences located in the Rolla region

is a growing firm reaching more than 200 employees that brings innovative solutions for environmental and homeland security applications using its strengths in microelectronics and polymers to advance remote sensing and biomaterials. To date, the company has been awarded 30 Small Business Innovation Research (SBIR) contracts, with a return of \$30 in sales for every \$1 in SBIR funding to develop new products. The specialized technology company database, maintained by Corptech, reports more than 60 environmental companies across the state.

Key Challenges: Challenges include maximizing the potential of Missouri institutions and companies to contribute to homeland security opportunities and positioning the existing industry of smaller companies with the growth of research drivers.

KEY POLICY ISSUES THAT MISSOURI NEEDS TO ADDRESS TO LEVERAGE ITS CORE RESEARCH STRENGTHS

The assessment of core research strengths and their development implications raises a number of critical policy issues that Missouri needs to address.

There is a significant need for continued investment in the life sciences and related research areas. Missouri’s second-tier status in life science research levels is not consistent with its ambitions to build its 21st century economy on the strength of the life sciences. Missouri needs to follow through on the plans of its research universities to expand their life science research efforts, with key equipment, core labs, and faculty, even in these times of limited budget resources. These investments are for the future and if shortchanged will reduce the state’s economic prospects. Simply put, in hard times, the need for smart choices in investments is critical.

Specific areas of emphasis should be those cross-cutting tool areas of bioinformatics, proteomics, bioengineering, and drug design and development, specifically combinatorial chemistry. Also, as suggested by the areas of bioinformatics and bioengineering, related disciplines involved in technology convergence with the life sciences need to be strengthened. Rather than trying to build deep strength across information technology and engineering, however, it is recommended that investments in these areas be done to complement the state’s strong focus on life science research.

There is a need for a predictable source of bioscience research facility funding in the University of Missouri System. Along with enhanced funding for life science research across institutions in the state, Missouri needs a more predictable way to fund research facilities, which are the life blood of a growing research program. There is a particular need for specialized facilities, such as advanced instrumentation and animal facilities, which can be jointly accessible to researchers from across institutions in a region. Currently, Missouri’s facility funding suffers from having one-year budgets that get reprioritized each year, and provide less than full funding for facilities, causing delays in completing projects. The following specific examples illustrate the need for a predictable source of facility funding:

- The University of Missouri-Kansas City’s (UMKC’s) new \$38 million Health Sciences Building received \$30.5 million in state funding in FY 2001, although only \$1.7 million has been released. UMKC now has to raise an additional \$7.6 million in non-state sources, which is not only a burden but slows down development.

- Missouri has only a one-year budget for university capital spending. Reprioritizing the budget every year leads to lack of predictability.
- There is a significant need for animal facilities in Kansas City.

There is a need to seize the opportunity for promoting cross-institutional collaborations to advance core focus areas and translational research. As Missouri invests in life science research, it can leverage growing strengths found across research institutions in the state. For instance, UMKC brings significant strengths in structural biology, a key discipline for proteomics, which should be leveraged by other research institutions across the state. Moreover, both the Stowers Institute for Medical Research and the Danforth Plant Science Center are developing basic research strengths, which can benefit from closer ties to medical schools to conduct clinical research for applications to improve human health. A particular challenge for Missouri is to develop public-private institution and bi-state collaborations, given the presence of leading private institutions such as Saint Louis University, Washington University, the Stowers Institute for Medical Research, and the Danforth Center, as well as the presence of the University of Kansas.

There is a growing need to support commercialization along with enhanced research efforts. Given that so much of the potential development foreseen in Missouri in the life sciences will be driven by new start-ups, it is critical that Missouri be a leader not only in research but in commercializing its research base. Initiatives to enhance technology transfer, to establish proof-of-concept research and formation of new start-up companies, and to support incubation services to grow early-stage companies are needed. It is important that commercialization initiatives be established along with the research investments so that the culture of moving from basic research to commercialization can be reinforced.

Assessment of Missouri’s Competitive Position

KEY SUCCESS FACTORS

The San Francisco Bay Area, Boston, the Baltimore/Washington region, the New York/New Jersey metro area, and San Diego are generally regarded as the nation’s premier bioscience centers. An examination of these regions shows that they share the following characteristics:

- ***Engaged universities with active leadership.*** An outstanding research university is required to become serious about the life sciences. But it takes more than simply research stature. It requires the capability to engage industry, directly or indirectly, to convert this intellectual knowledge into economic activity. To do so requires one or more of a region’s research universities committed to engage with and help build and sustain a life science community locally. To succeed, a region must have a university that has already made this commitment or a state government committed to using discretionary R&D funding to *induce its public and private research universities to undertake that commitment.*
- ***Intensive networking across sectors and with industry.*** As many observers of high-tech clusters have noted, the most successful clusters facilitate extensive and intensive networking among technology companies and their managers and employees. In a very few leading communities like Silicon Valley, this networking has occurred naturally, with formal organizations like Joint Venture-Silicon Valley coming only later. However, in the vast majority of American regions, such organizations need to be *built* from the ground up; otherwise, the desired degree, scale, and intensity of networking will not occur.
- ***Available capital covering all stages of the business cycle.*** Leading life science regions share one characteristic: they are home to a venture capital community that is both oriented toward early-stage financing and committed to local investment. Having local venture capital funds with experience investing in bioscience companies is critical. These regions also have networks of successful entrepreneurs who act as angel investors, willing to invest in very early stage start-up companies. Such investments, commonly referred to as “pre-seed/seed capital,” provide equity financing in the range of \$200,000 to \$2 million. It is also critical to have financing available for each stage of development from early-stage, proof-of-concept, and prototype development to product expansion and later-stage venture financing.
- ***Discretionary federal or other R&D funding support.*** To build generic R&D assets into an effective attractor of technology investment requires leverage of substantial, ongoing, external, discretionary funding. While technology leaders like Silicon Valley, Route 128 in the Boston area, and San Diego were able to leverage decades of heavy defense contracting,

Key Success Factors

- Engaged universities with active leadership
- Intensive networking across sectors and with industry
- Available capital covering all stages of the business cycle
- Discretionary federal or other R&D funding support
- Workforce and talent pool on which to build and sustain efforts
- Access to specialized facilities and equipment
- Stable and supportive business, tax, and regulatory policies
- Patience and a long-term perspective

and while Baltimore/Washington leveraged growing congressional support of federal laboratories owned by NIH, the National Institute of Standards and Technology (NIST), and the Food and Drug Administration (FDA), most regions must use state funding as a lever for acquiring strategic external investments.

- ***Workforce and talent pool on which to build and sustain efforts.*** Like any knowledge-based industry, life science companies need a supply of qualified, trained workers. To meet the demands of newly emerging fields, new curricula and programs need to be developed by educational institutions working in close partnership with the life science industry. In addition to having world-class researchers, successful life science regions have an adequate supply of management, sales, marketing, and regulatory personnel experienced in the life sciences.
- ***Access to specialized facilities and equipment.*** Facility costs are among the most significant expenses of a new life science firm. These firms need access to wet-lab space and specialized equipment. Since most life science firms initially lease space rather than purchase it, an available supply of facilities (such as privately developed multitenant buildings) offering space and equipment (such as incubators and accelerators) for life science companies is critical.
- ***Stable and supportive business, tax, and regulatory policies.*** Life science companies need a regulatory climate and environment that encourage and support the growth and development of their industry. Tax policies that recognize the long development cycle required to bring new bioscience discoveries to the market can provide additional capital for emerging companies, as well as ensuring an even playing field in state and local tax policies between older, traditional industries and emerging industries such as the life sciences.
- ***Patience and a long-term perspective.*** One final lesson from every successful technology community is that success takes time. Silicon Valley and Route 128 trace their origins in electronics to the 1950s and in the life sciences to the 1970s. Research Triangle Park represents a 50-year strategy that has only recently found its footing in the life sciences and is still working to develop full capability in the entrepreneurial sector. In contrast, Maryland has emerged as a major bioscience center in 12 to 14 years. While this may indicate that the time required to become a leading life science center can be shortened, it must be recognized that such development cannot be accomplished in a year or two. It requires a long-term effort.

Table 2: Life Science Regional Factors of Success

Factor of Success	Best Practice Regions	Missouri Situation
Engaged Universities	Research universities are engaged in regional economic development, from incubators and accelerators to research parks and tech commercialization. Best practices include commercialization funds, pre-seed funds, and tech commercialization support services.	Missouri has no programs to support commercialization activities or to encourage greater interaction between university researchers and industry. Missouri’s Centers for Advanced Technology (CATS) program helped companies pay for research conducted by a state university, but this program is no longer funded.
Intensive Networking	Active technology intermediary organizations provide a focal point for the state’s biotechnology efforts. These organizations play a critical role in networking academic, industry, and public and nonprofit groups and organizations, encouraging cross-fertilization of ideas and opportunities and leading, in many cases, to joint endeavors. They also help link business service providers and their knowledge of critical aspects of business formation and maturation with bioscience firms.	The newly established Missouri Biotechnology Association (MOBIO) provides networking opportunities for Missouri’s life science companies, and both Kansas City (KC Catalyst) and St. Louis (Technology Gateway Alliance) have established networking organizations as well.
Available Capital	As the number of venture capital funds have increased across the nation, it has fallen on states and regions to address the commercialization, pre-seed, and seed financing gaps to help establish and build firms in their early years that might be suitable for venture capital financing in later life cycles. This trend is true in entrepreneurial “hot beds” as well as less mature regions.	Prolog Ventures has been established as a statewide seed venture fund, taking advantage of a state-authorized tax credit program, and a number of other state tax credit programs provide direct or indirect assistance to encourage venture investments. St. Louis has actively implemented its Plant and Life Sciences Strategy in the past two years, and over \$250 million has been raised by three funds located in Missouri to make investments in the life sciences.
Discretionary R&D Funding	Every major technology region in the United States has received significant federal discretionary funding and/or has federal centers or institutes that helped “anchor” their technology base, attracting and spinning off firms and technologies.	Missouri has no major federally funded stand-alone research centers such as an NIH or a CDC; however, Washington University receives significant NIH funding.
Skilled Workforce	Educational institutions at all levels must be responsive to training students to meet the needs for bioscience workers at all skill levels including scientists, technicians, and production workers.	Missouri’s proposed Mathematics Academy is an initiative that can contribute to training students for careers in the life sciences. In addition, Missouri has given priority in mission enhancement funds for the University of Missouri System and in discretionary funding to community colleges to address some curriculum changes and program development for the life sciences.

Table 2: Life Science Regional Factors of Success (continued)

Factor of Success	Best Practice Regions	Missouri Situation
Specialized Facilities and Equipment	Leading bioscience regions have private real estate markets that provide facilities offering space for bioscience companies. Incubators and research parks focused on bioscience companies are common. In fact, eight states in the nation have research parks dedicated solely to fostering life science companies.	While Missouri has several research parks, including the Missouri Research Park in St. Charles, the University of Missouri Research Park in Fort Leonard Wood, and the University of Missouri Research Park at Columbia, it has no parks dedicated solely to the life sciences. Missouri has two dedicated plant and life science incubators in St. Louis (NIDUS, Center for Emerging Technologies), which are at or near capacity. However, no similar facility currently exists elsewhere in the state. The Kansas City Center for Technology, which will include wet-lab space, is currently being planned.
Patience and a Long-Term Perspective	While the early technology regional pioneers each took 25 years to develop, more recent examples such as Maryland took 12 to 14 years to mature.	Both St. Louis and Kansas City have recently completed comprehensive strategies for positioning their regions as major centers in the life sciences and are actively implementing these plans. Missouri, working in concert with these and all other regions of the state, can become a major life science center, but must recognize time and patience are required. Building on these regional efforts creates a united “One Missouri” that should increase scale, intensity, and speed in implementation of such a vision.

COMPARING MISSOURI WITH THE BENCHMARK STATES

This section assesses Missouri’s competitive position on these key success factors vis-à-vis seven states that have established, or emerging, life science sectors or that are trying to develop a life science sector. The benchmark states include Illinois, Maryland, North Carolina, Ohio, Oklahoma, Pennsylvania, and Texas. Maryland and North Carolina were chosen because these states have become leading centers for the life sciences. Both states have made significant investments over a 15- to 20-year period and both have met with considerable success. Pennsylvania was chosen because the state has an emerging bioscience cluster and is actively seeking to encourage its growth. Illinois, Ohio, Oklahoma, and Texas were chosen because these states are considered regional competitors to Missouri and each have metropolitan areas with initiatives underway to encourage the development of their life science sectors. All of the states in the benchmark set have more than one metropolitan area that is actively pursuing development of the life sciences.

The approaches taken by each of these states to grow their life science base and the level of state government involvement vary considerably. **North Carolina**, which created the North Carolina Biotechnology Center 20 years ago, and **Maryland**, which adopted a Commercial Biotechnology

Benchmark States

- Illinois
- Maryland
- North Carolina
- Ohio
- Oklahoma
- Pennsylvania
- Texas

Strategy 10 years ago, have the most long-standing state-supported efforts to promote the growth of the bioscience industry. Both states have invested in developing strong university-based life science research capabilities but also provide assistance and financing to start-up technology companies.

Pennsylvania's efforts to grow its life science base are more recent. The Commonwealth is using tobacco settlement funds to fund life science research, create a life science venture fund, and establish three Life Sciences Greenhouses. *Illinois* is investing in R&D infrastructure at the state's universities through VentureTECH, a \$1.9 billion initiative. In addition, the state is establishing commercialization centers and investing in seed capital funds. *Ohio* has announced a 10-year, \$1.6 billion Third Frontier initiative, including support for the biosciences.

Oklahoma's Center for the Advancement of Science and Technology (OCAST) operates a series of modest programs in R&D capacity building. Recently, the Governor initiated the creation of a \$100 million trust fund that would increase these efforts by a significant order of magnitude. Meanwhile, the state continues to emphasize a vigorous program of commercialization assistance centers, linked to a public source of seed-stage financing.

Texas has operated a significant competitive R&D capacity program for many years, although it is not targeted specifically to the life sciences. The most current activity to develop the life sciences in Texas is occurring at the metropolitan level, specifically in Houston and San Antonio. San Antonio has a biotechnology research park, and Houston is planning one, based on its heavy concentration of academic medicine facilities and entrepreneurial leadership from the president of the M.D. Anderson Cancer Center.

Building R&D Capacity in the Life Sciences

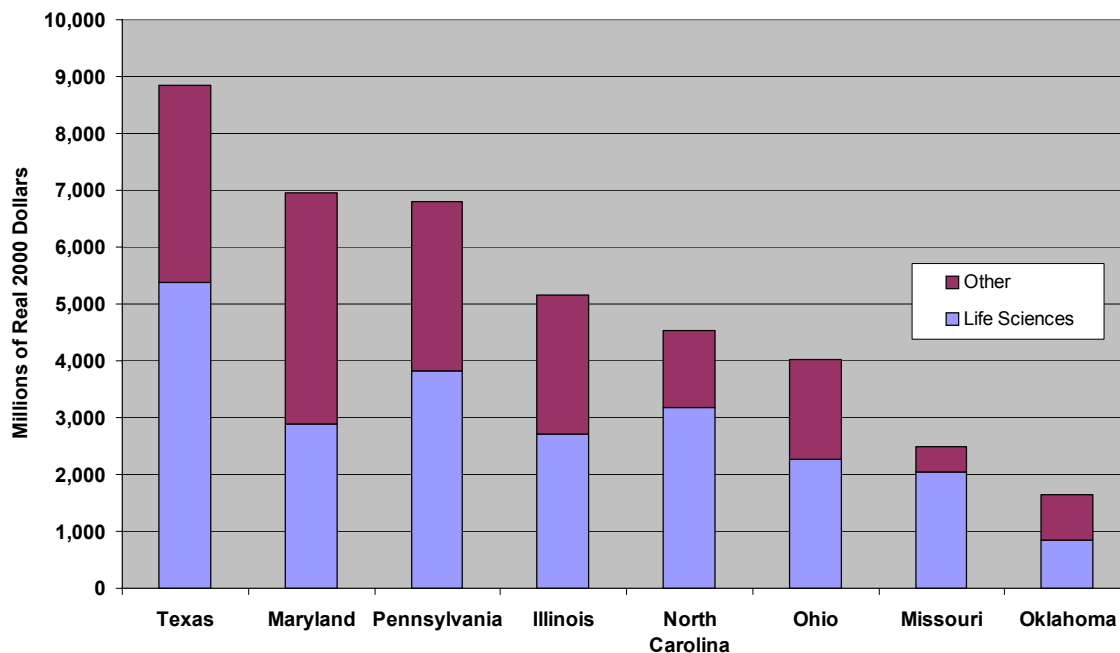
Missouri's bioscience R&D base is less well-developed than those of the benchmark states. However, Missouri's life science academic research and development is growing faster than most of the benchmark set. Missouri ranks seventh among the benchmark states in terms of total academic life science, R&D but it experienced the third highest growth rate in life science R&D funding between FY 1995 and FY 1999 (Figures 8 and 9).

Normalizing total academic R&D by gross state product (Figure 10) shows that Missouri ranks seventh among the benchmarks and behind the United States as a whole.

A summation of FY 1995-1999 data on a per capita basis (see Figure 11) shows that, while Missouri ranks fifth in terms of total R&D, it ranks third in bioscience R&D.

While Missouri's total level of NIH funding is less than most of the benchmark states, Missouri experienced extremely rapid growth in NIH funding compared with the benchmark set. Missouri ranks seventh among the benchmark states and 12th nationally in terms of NIH awards received between FY 1997 and 2000 (Figure 12). However, Missouri experienced the second highest growth rate in NIH awards during this time period, with only Texas experiencing a larger percentage increase.

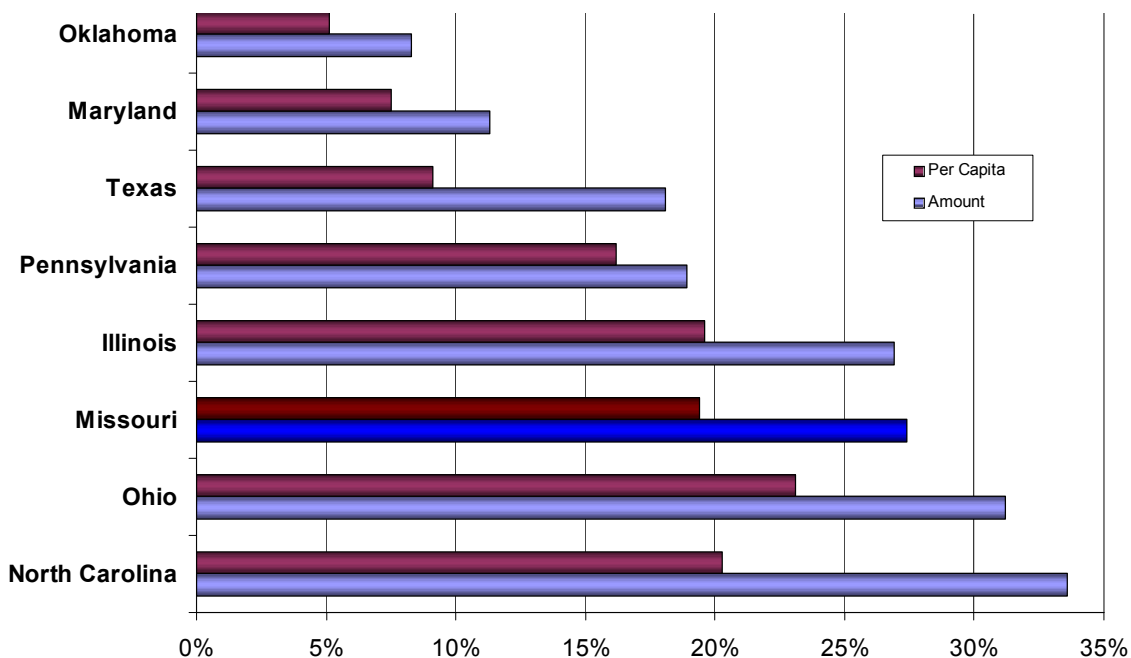
Figure 8: Life Science and Total Academic R&D, FY 1995-1999



Source: National Science Foundation.

Note: Southern Illinois University is included within the State of Illinois, although the university is located within the St. Louis metropolitan area; Southern Illinois University reported only \$610,000 in bioscience R&D from 1995-1999. The Missouri data does not include Kansas City, Kansas, because NSF data are not reported separately for the University of Kansas Medical Center.

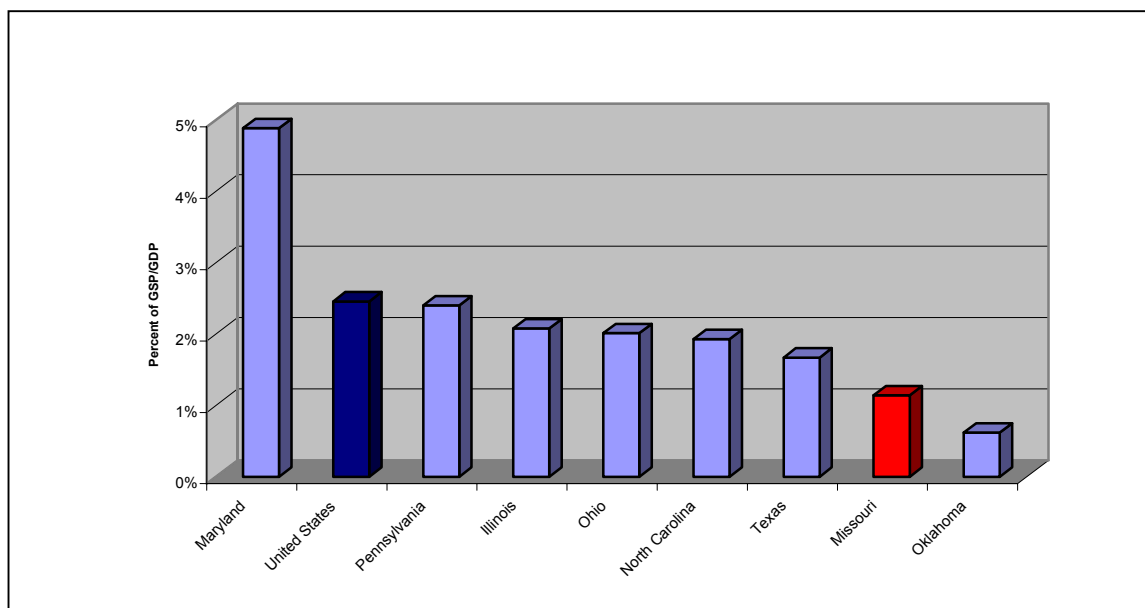
Figure 9: Percent Change in Life Science Academic R&D, FY 1995-1999



Source: National Science Foundation.

Note: Southern Illinois University is included within the State of Illinois, although the university is located within the St. Louis metropolitan area; Southern Illinois University reported only \$610,000 in bioscience R&D from 1995-1999. The Missouri data does not include Kansas City, Kansas, because NSF data are not reported separately for the University of Kansas Medical Center.

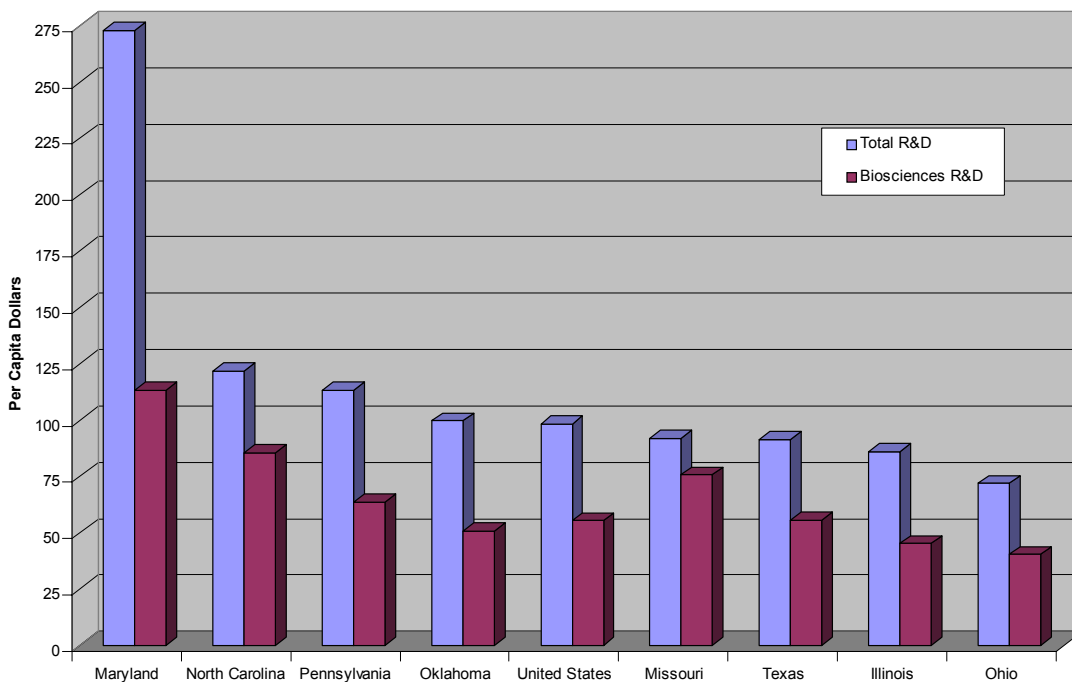
Figure 10: Total R&D as Percent of Gross State Domestic Product, FY 1998



Source: National Science Foundation.

Note: The portion of the Kansas City SMSA and the Illinois portion of the St. Louis SMSA are not included in the Missouri data because the data are reported on a state basis.

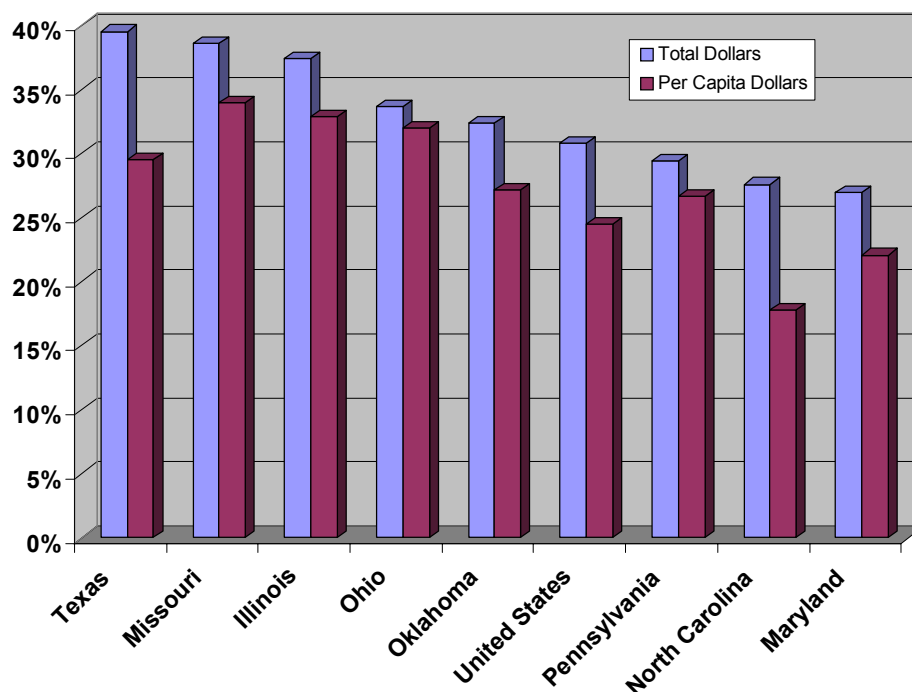
Figure 11: Academic R&D Per Capita, FY 1995–1999



Source: National Science Foundation.

Note: Southern Illinois University is included within the State of Illinois, although the university is located within the St. Louis metropolitan area; Southern Illinois University reported only \$610,000 in bioscience R&D from 1995-1999. The Missouri data does not include Kansas City, Kansas, because NSF data are not reported separately for the University of Kansas Medical Center.

Figure 12: Percent Change in NIH Dollars, Total and Per Capita, FY 1997-2000



Source: NIH

Note: The Kansas portion of the Kansas City SMSA and the Illinois portion of the St. Louis SMSA are not included in the Missouri data because the data are reported on a state basis.

Five of the benchmark states have developed explicit initiatives to increase the level of life science R&D captured by their academic and research institutions. These initiatives do not support research for its own sake—duplicating the NIH or NSF at the state level—but rather attempt to use state support as a lever to achieve several interrelated objectives:

- Expansion of physical capacity for bioscience research (i.e., laboratory buildings or specialized equipment that cannot be bought on federal grants but are necessary to obtain them), allowing the state to “track” expected growth in funding from the NIH or even expand its market share
- Development of research faculty, including both start-up assistance to junior faculty who might one day become large federal grantees and “packages” necessary to attract more senior faculty who bring with them existing large portfolios of federal funding
- Creation of links between academic disciplines and among various research institutions, allowing access to federal programs that favor such cooperation or that require a wider range of intellectual or physical resources than any one institution can provide
- Provision of matching funds to attract federal R&D support that requires state or local matching

- Development of a cadre of well-trained graduate students and postdoctoral students who upon leaving academia may form the nucleus for a range of entrepreneurial life science start-ups
- General improvement in the reputation of the state as a center of the biosciences, enhancing its legitimacy in the eyes of those executives who determine the placement of R&D investments by large corporations.

Examples of the investments that the benchmark states are making to build their research capacity in the life sciences include:

- In 2001, the **Illinois** state legislature approved \$200 million to fund R&D facilities including a Post-Genomics Institute at the University of Illinois, a Biomedical Research Facility on the University of Illinois Chicago campus, a Medical Resonance Imaging Center and a Chemical Sciences Building in Chicago, and a Biomedical Research Building at Northwestern University.
- **Maryland** created the University of Maryland Biotechnology Institute (UMBI), a quasi-independent unit of the University of Maryland, in the mid-1980s to attract federal R&D funding. Between FY 1991 and FY 2001, Maryland invested more than \$60 million in UMBI, which is composed of five research centers.
- **Pennsylvania** is investing a portion of the state’s tobacco settlement funds (\$160 million in one-time costs and \$60 million annually) in three regionally based Life Science Greenhouses. These university/industry/state partnerships will conduct research and seek to commercialize life science technologies.

Knowledge Transfer and Commercialization

Having a strong bioscience research base is necessary, but not sufficient to become a bioscience leader. Regions with strong bioscience sectors have established mechanisms that promote the transfer of knowledge from universities and laboratories to industry. Much of Silicon Valley’s success, for example, is attributable not only to the world-class research conducted at Stanford University, but also to Stanford’s policy of encouraging its faculty and students to commercialize research they developed.

Table 3 shows technology transfer activity measures for those Missouri institutions of higher education that responded to a survey of the Association of University Technology Managers (AUTM). The data show that Washington University and the University of Missouri System exceed the medians reported by survey participants in several categories. In particular, Washington University ranks well in the number of new start-up companies formed based on university-developed technology, although still below the top quartile of states on this measure. Between FY 1996 and FY 1999, Washington University created nine new companies.

Normalizing the results by the size of each institution’s R&D budget (i.e., per \$10 million of sponsored R&D), Washington University’s performance is impressive in terms of licenses executed, but the University of Missouri’s is less so. Adjusting for its smaller size, Saint Louis University beats the median in both disclosures and patents issued.

Table 3: Technology Transfer Activities in Missouri Universities in FY 1996-1999

	Washington University	University of Missouri System	AUTM Median	AUTM Top Quartile
Sponsored Research Expenditures	\$1,195,140,521	\$717,830,399	\$597,199,049	\$936,505,150
Invention Disclosures	210	244	220	419
Patent Applications Filed	296	124	133	274
Patents Issued	118	57	52	100
Licenses and Options Executed	243	68	46	130
Licenses Yielding Income	450	73	102	238
Gross License Income	\$29,189,351	\$6,206,373	\$4,960,480	\$16,137,559
Start-Ups	9	1	5	12
Disclosures per \$10 million R&D	1.76	3.40	4.21	5.32
Patents Issued per \$10 million R&D	0.99	0.79	1.00	1.52
Licenses Executed per \$10 million R&D	2.03	0.95	0.95	1.72
Average Income per License	\$64,865	\$85,019	\$42,632	\$72,153
Start-Ups per \$10 million R&D	0.08	0.01	0.09	0.16
Start-Ups per License Executed	0.04	0.01	0.10	0.15

Note: All dollar amounts are real 2000 dollars.

Source: Association of University Technology Managers (AUTM) Survey, Battelle calculations.

Another indicator of a region’s ability to turn discoveries into commercial products is the number of patents issued. On this measure, Table 4 shows that Missouri ranks seventh in the number of bioscience patents³ issued to its inventors in both FY 2000 and the period from FY 1996 to FY 2000. Patent issuance increased 36 percent over this period, but this growth rate lagged that of the nation as a whole and about half the benchmark set.

Table 4: Bioscience-Related Patents, FY 1996-2000

	Bioscience Related Patents FY '00	Avg. Bioscience Patents '96-'00	Percent Change of Bioscience Patents '96-'00	Bioscience Related Patents as a % of All Patents FY '96	Bioscience Related Patents as a % of All Patents FY '00	State Share of Total U.S. Bioscience Patents 1996	State Share of Total U.S. Bioscience Patents 2000
Illinois	656	568	28.1%	16.3%	17.1%	4.6%	3.9%
Maryland	499	494	51.7%	29.9%	36.8%	2.9%	3.0%
Missouri	213	218	35.7%	23.9%	25.9%	1.4%	1.3%
North Carolina	327	287	45.3%	18.9%	17.7%	2.0%	1.9%
Ohio	548	536	30.8%	16.0%	17.1%	3.8%	3.3%
Oklahoma	94	89	11.9%	17.5%	17.3%	0.8%	0.6%
Pennsylvania	834	762	38.8%	20.6%	22.9%	5.4%	5.0%
Texas	788	671	63.8%	11.5%	12.5%	4.3%	4.7%

Source: United States Patent and Trademark Office.

Note: The Kansas portion of the Kansas City SMSA and the Illinois portion of the St. Louis SMSA are not included in the Missouri data because the data are reported on a state basis.

³ In this analysis, “bioscience-related” is defined using the U.S. Patent and Trademark Office Classification system, which is described in the benchmarking appendix.

The benchmark states have undertaken a number of initiatives designed to encourage greater interaction between researchers and industry and to facilitate the commercialization of university-developed research. They include providing financing for collaborative university/industry research projects and providing support for pre-commercialization activities such as feasibility studies, proof-of-concept tests, prototype production, and other reduction-to-practice challenges. In some states (e.g., Pennsylvania), such grants are repayable on certain conditions by the private sector partner who may commercialize the results of the research. The following are examples of initiatives within the benchmark states that provide support for university/industry research projects:

- The **Maryland Technology Development Corporation** operates two programs aimed directly at forging “partnerships”: one between companies and universities and the other between companies and federal laboratories, in which the state is richly endowed. In addition, the Maryland Industrial Partnerships (MIPS) Program provides matching grants for university/industry research projects. In FY 2001, MIPS was funded at \$2.3 million.
- The **North Carolina Biotechnology Center** offers Collaborative Funding Assistance Grants to faculty to encourage university/industry partnerships and business loans to address the issue from the other side of the partnerships.
- The **Oklahoma Applied Research Support (OARS) Program** was initiated to accelerate the development of technology (including biotechnology) with potential for producing a commercially successful product, process, or service that will benefit Oklahoma’s economy. OCAST, through the OARS program, provides incentive funding to applied research projects under terms that increase industrial R&D investment and reward collaborative efforts.

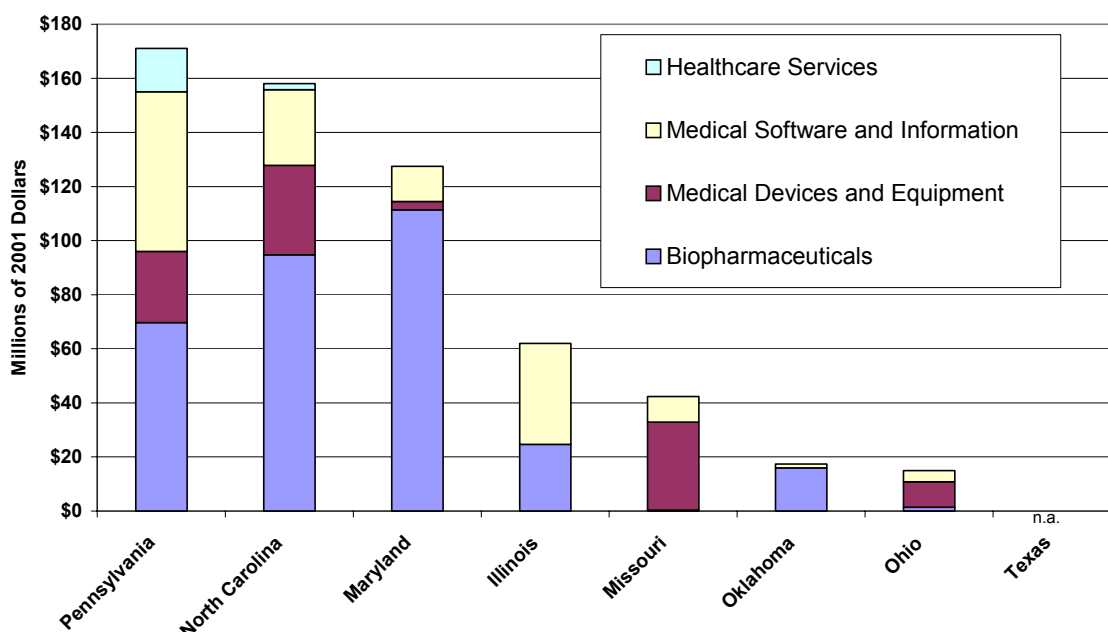
Many of the benchmark states also provide funding to universities to support the additional activities needed to determine the commercial potential of research discoveries. The North Carolina Biotechnology Center, for example, awards to universities “Proof of Principle” grants of up to \$25,000 for commercialization research. Some universities have developed these mechanisms internally. For example, Ohio State University has created an OSU Technology Commercialization Company that provides pre-seed funding for commercialization research connected with OSU technology.

Missouri currently has no programs that support university/industry research or reduction to practice or proof-of-concept activities.

Risk Capital

Pennsylvania, North Carolina, and Maryland dominate in terms of life science venture capital investments, receiving \$171 million, \$158 million, and \$127 million in 2001, respectively (Figure 13). Missouri life science companies received \$42.4 million in venture capital in 2001. Missouri also differs from the benchmark states in the distribution of venture capital investments by industry sector. More than three-quarters of the venture capital invested in Missouri life science companies in 2001 was invested in medical device and equipment companies. Maryland life science venture capital investments are heavily focused on the biopharmaceutical sector, while Pennsylvania has significant levels of investment in both biopharmaceuticals and medical software and information. It should be noted, however, that the entire \$58 million invested in the past two years in medical device and equipment companies in Missouri has been entirely devoted to Stereotaxis in St. Louis.

Figure 13: Bioscience Venture Capital by Industry, 2001



Source: MoneyTree Survey, PricewaterhouseCoopers.

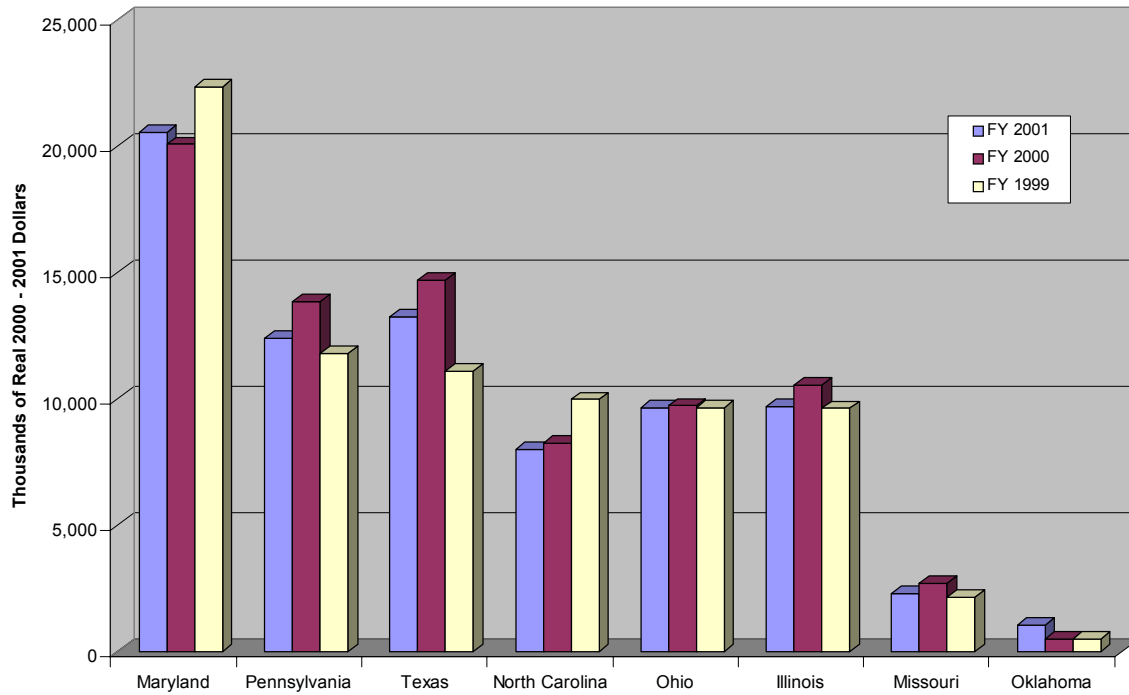
Note: Data for Medical Software and Information is only for the first three quarters of 2001.

Note: The Kansas portion of the Kansas City SMSA and the Illinois portion of the St. Louis SMSA are not included in the Missouri data because the data are reported on a state basis.

Another important source of risk capital is the federal Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) program. This program requires all federal agencies with annual extramural research and development budgets of more than \$100 million to set aside 2.5 percent of those monies to competitively fund innovative research conducted by small businesses. Since it was initiated in 1982, the SBIR program has grown to become the single largest source of competitive early-stage research and technology development funding in the country for small businesses. Today, the SBIR program awards more than \$1 billion annually. One way to gauge the level of bioscience research occurring in a state is to examine the number of NIH SBIR awards going to a particular region or state.

In dollar value of SBIR and STTR awards received from NIH in the last three reporting years (see Figure 14), Missouri ranks far behind all the benchmark states except Oklahoma. By contrast, some of the benchmark states are at or near the top of the national distribution. Maryland receives more than \$20 million each year, exceeding Missouri's number by an order of magnitude. Looking also at SBIR awards from the U.S. Department of Agriculture (USDA) as a proxy for plant science activity, Figure 15 shows that Missouri surpassed only Pennsylvania and Illinois in FY 2000 and registered no success at all in FY 2001. Generally speaking, a downward trend occurred in all the benchmark states, but variability occurred from a higher base in more than half the set.

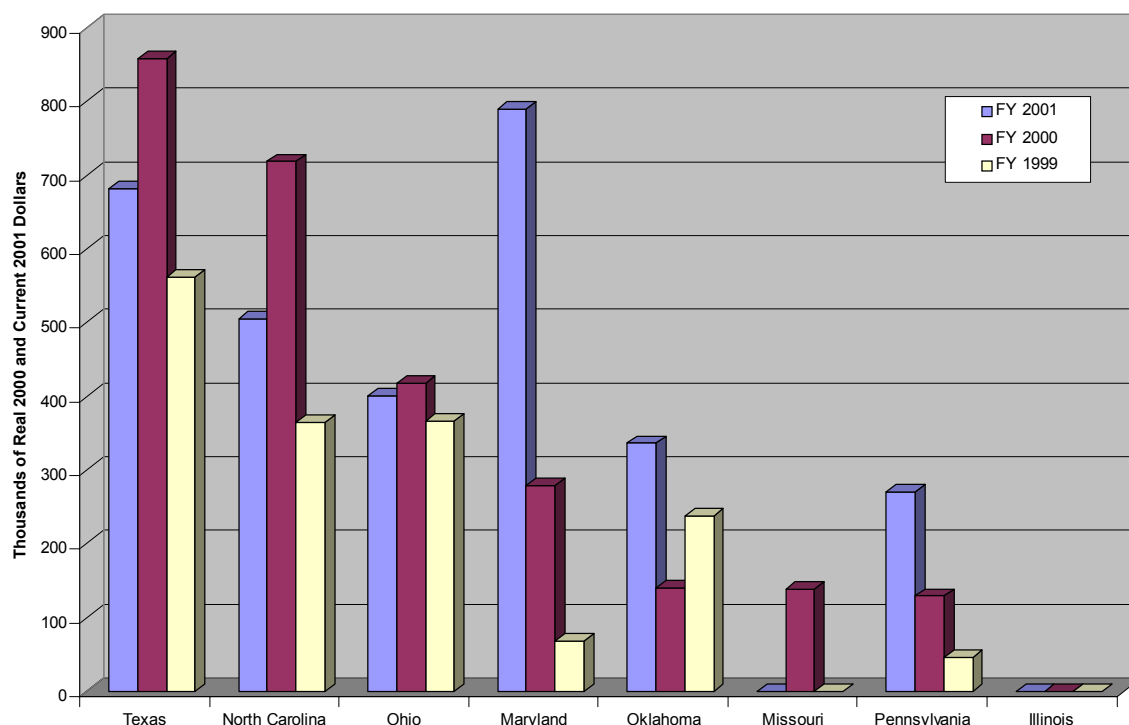
Figure 14: National Institutes of Health Phases I and II SBIR and STTR Awards



Source: National Institutes of Health

Note: The Kansas portion of the Kansas City SMSA and the Illinois portion of the St. Louis SMSA are not included in the Missouri data because the data are reported on a state basis.

Figure 15: Department of Agriculture SBIR Awards



Source: United States Department of Agriculture

Note: The Kansas portion of the Kansas City SMSA and the Illinois portion of the St. Louis SMSA are not included in the Missouri data because the data are reported on a state basis.

Relying exclusively on the private venture capital market to finance the pre-seed/seed stages of *any* technology venture is now widely understood to be a barrier to building a critical mass of firms in a region or state that can lead to missed business opportunities. The scale requirements of the venture capital business and the risk/return preferences of its institutional investors preclude the kind of intensive due diligence and ongoing involvement necessary for successful seed-stage investing. Today’s funds are too large to do small deals, and staffing is not usually sufficient to handle small investments. These difficulties are amplified in the bioscience sector, where ventures often must survive (and finance) a long and grueling sequence of preclinical and clinical testing before any product can generate revenue.

States use a variety of strategies to increase the availability of pre-seed/seed stage risk capital. Approaches include

- **Encouraging locally managed venture funds.** Some states have intervened in the private venture-capital marketplace to encourage the creation of locally managed firms, or at least offices of major national firms. Maryland’s Venture Capital Trust, for example, is a “fund of funds” that allows state and City of Baltimore pension funds to invest in a diversified pool of professionally managed venture funds whose members have agreed to open Maryland offices and to make a good faith effort to invest in Maryland companies. Such programs can improve the investment environment for firms that face barriers because so little institutional capital is

being managed locally, but they do not in and of themselves cause venture funds to target either early-stage businesses or bioscience businesses.

- ***Encouraging creation of pre-seed/seed stage funds.*** Some states have used their investing power to catalyze formation of locally managed funds that are fully committed to early-stage investment. State government may provide an initial capitalization for the fund with additional capital raised from local investors that may include individuals, foundations, university endowments, and major corporate citizens. North Carolina’s Bioscience Investment Fund was created by the North Carolina Biotechnology Center and is managed by Eno River Capital in Durham. The fund, which provides seed capital to bioscience companies, was capitalized with \$10 million in appropriations from the North Carolina General Assembly and has reached \$25 million with the help of outside investors.
- ***Investing in direct or indirect quasipublic seed funds.*** The most aggressive strategy is to invest in seed-stage enterprises directly through a state agency or indirectly through a quasipublic authority or state-chartered nonprofit. Initiatives in this category include the investment programs run by the nonprofit Connecticut Innovations, the Illinois Development Finance Authority, the Maryland Department of Business and Economic Development, and the North Carolina Technological Development Authority. In all these cases, bioscience is just one of the fields entertained. In both Connecticut and Maryland, an initial flow of appropriations has been replaced by reinvestment of realized gains, predominantly from the information technology (IT) sector.

All of the benchmark states have undertaken multiple initiatives to increase the availability of seed and venture capital. In Illinois, Maryland, Ohio, and Pennsylvania, public pension funds have invested in local venture capital funds. Illinois, Maryland, North Carolina, Ohio, Oklahoma, and Pennsylvania have created privately and publicly managed funds whose initial capitalization was provided by state government. These initiatives are described in the *Missouri Benchmarking Analysis*.

Missouri has taken some initial steps to increase the availability of seed and venture capital. Prolog Ventures has been established as a statewide seed venture fund, taking advantage of a state-authorized tax credit program, and a number of other state tax credit programs provide direct or indirect assistance to encourage venture investments. St. Louis has actively implemented its Plant and Life Sciences Strategy in the past 18 months, and over \$150 million has been raised by three funds located in Missouri to make investments in the life sciences.

Technology Infrastructure

Like the capital markets, the commercial real estate markets tend not to supply, of their own accord, what bioscience firms need to grow: namely, inexpensive, wet-lab-equipped space zoned for research and process scale-up but situated very close to the research institutions and their key faculty who may serve as consultants or advisors. Given the high capital costs involved in constructing permitted laboratory space, candidate parcels are often considered to have some other higher and better use, judging by risk-adjusted expected returns. Almost any developer will eagerly build wet-lab space for a credit-worthy single tenant (assuming available land and zoning); but, barring the exceptional inward recruitment of a major biotech firm, this is not the issue facing most communities trying to build a bioscience cluster. Rather, the problem lies in

financing incubator and multitenant space for tenants who are not credit-worthy and whose concepts have not been proved in the marketplace.

Each of the benchmark states has created one or more technology-oriented research parks.

These parks sometimes, but not always, include a university-affiliated incubator and almost always involve some kind of public subsidy, either capital (land, mortgage, building construction) or operating (cash flow from incubators, loan guarantees, commitments to surge-space rental, etc.). Among the benchmark states, Maryland has been most active in helping life science companies access the facilities and equipment they need.

Maryland is home to a network of incubators, seven of which are focused on biotechnology and life science companies. In total these incubators include more than 50,000 square feet of laboratory space. The Shady Grove Life Science Center, a research park developed with county and state support, houses not only corporate tenants but also the University of Maryland Biotechnology Institute’s Center for Applied Research in Biotechnology (a University of Maryland facility in which 11 different universities and colleges offer graduate and undergraduate courses), a campus of Johns Hopkins University, and an incubator.

In addition, Maryland has used its traditional economic development programs, including a Sunny Day Fund, to assist life science companies in obtaining financing for facility development. These programs have been used to help companies construct laboratory facilities and purchase specialized machinery and equipment. The Maryland Industrial Development Finance Authority has played a key role in helping to meet the large capital needs of Maryland biotechnology companies as they scale up to manufacturing.

While Missouri has several research parks, including the Missouri Research Park in St. Charles, the University of Missouri Research Park in Fort Leonard Wood, and the University of Missouri Research Park at Columbia, it has no parks dedicated solely to the life sciences. Missouri has two dedicated plant and life science incubators in St. Louis (the Nidus Center and the Center for Emerging Technologies), which are at or near capacity. However, no similar facility currently exists elsewhere in the state. The Kansas City Center for Technology, which will include wet-lab space, is currently being planned.

Incentives and Tax Policy

No state among the benchmarks has implemented tax incentives or regulatory reform aimed specifically or exclusively at the bioscience industry; but, several have R&D tax credits, and others have determined that bioscience sectors are included among those targeted by initiatives aimed at R&D in general. Components found in some tax initiatives include

- Treatment of R&D equipment on a par with manufacturing equipment with respect to exemptions or abatements from sales or use tax on its purchase
- Treatment of R&D equipment on a par with manufacturing equipment with respect to exemptions or abatements from tax on its value as tangible business property (where such tax is levied on businesses)
- Tax credits for R&D expenditure—either incremental of a baseline or nonincremental—and carryforwards and/or sale of unused credits.

In addition, all research-oriented firms including bioscience tend to benefit from provisions that recognize net operating losses and the ability to carry forward and/or sell the same.

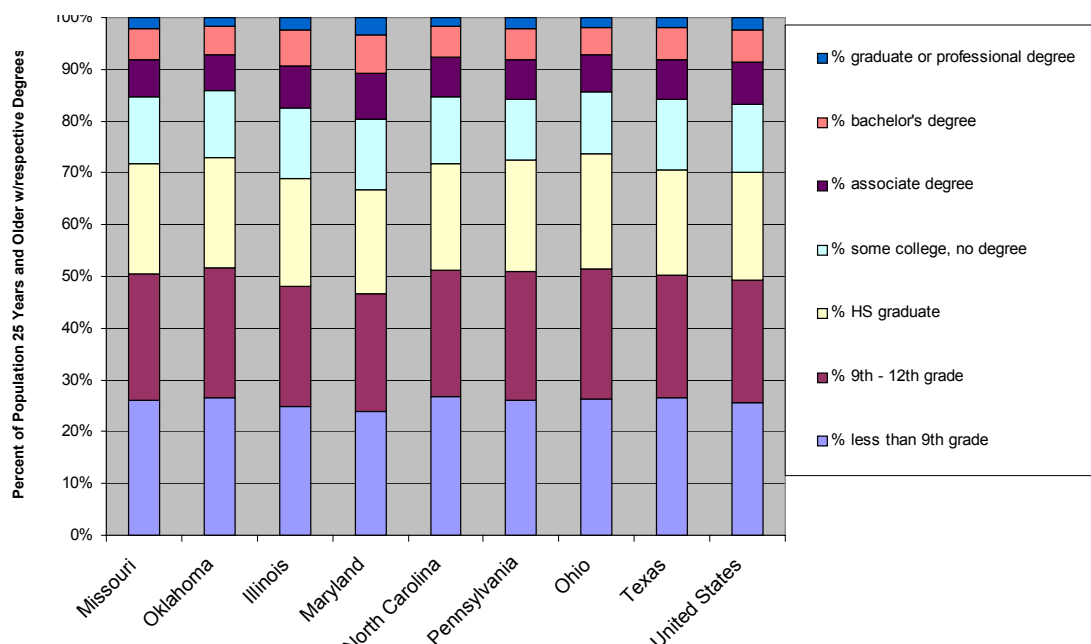
Missouri has a state R&D tax credit that is an effective vehicle for more established companies, even providing for transferability to assist companies that are not yet profitable. However, the R&D tax credit has limited availability to young life science companies because its benefit requires prior research expenses. Moreover, the capital tax credit program, providing a transferable tax credit to an investor in a qualified small business, including life science companies, has been exhausted for several years.

Workforce

Census data show (see Figure 16) that, in educational attainment of the population over 25, Missouri is on par with most of the benchmark states in most categories. Only Illinois and Maryland have higher percentages of their workforce holding graduate and professional degrees, and Missouri has about the same as Pennsylvania in this category. However, considering all who hold a bachelor's degree or higher, the national average is slightly higher than that of Missouri.

The National Center for Education Statistics data (Table 5 and Figure 17) show that, during the most recent academic year, Missouri graduated 12,135 students in bioscience-related disciplines, with the majority of those in clinical fields. All the benchmark states produced more than half their bioscience-related graduates in the clinical subfield (including nursing), with Oklahoma the highest at 70 percent. Missouri had the second-highest number of total bioscience degrees per 100,000 per capita at 217 versus 227 for Pennsylvania. However, compared with the bioscience workforces in each state, Missouri produces fewer bioscience research graduates per existing bioscience job than all but two of the benchmark states. In the clinical and support subfields, Missouri bests both North Carolina and Maryland, suggesting a possible niche for the state.

Figure 16: Educational Attainment, 2000 Estimates



Source: United States Census Bureau, Census 2000 Supplemental Survey

Note: The Kansas portion of the Kansas City SMSA and the Illinois portion of the St. Louis SMSA are not included in the Missouri data because the data are reported on a state basis.

Table 5: Bioscience Degrees, All Levels, 2000-2001 Academic Year

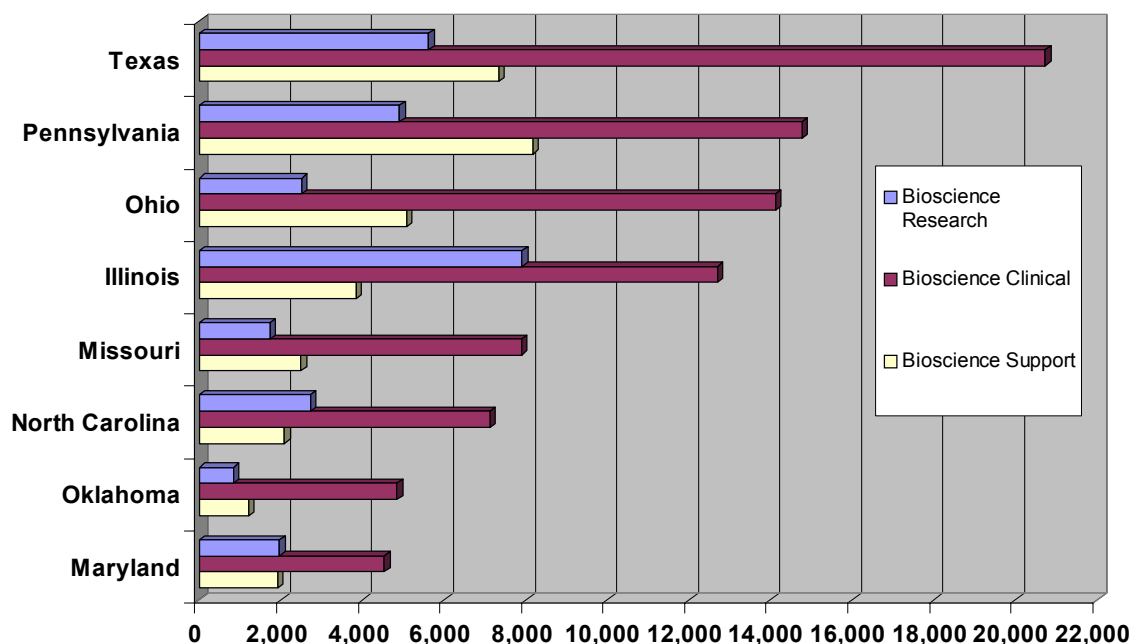
	Bioscience Research	Clinical	Bioscience Support	Bioscience Related Total	Degrees per 100,000 Capita		Degrees per 1,000 Bioscience Employment	
					Bioscience Research	Total	Bioscience Research	Total
Illinois	7,913	12,702	3,835	24,450	64	197	23.7	73.3
Maryland	1,969	4,542	1,930	8,441	37	159	15.3	65.4
Missouri	1,742	7,893	2,500	12,135	31	217	10.2	71.2
North Carolina	2,736	7,133	2,098	11,967	34	149	14.0	61.4
Ohio	2,514	14,138	5,085	21,737	22	191	8.4	72.4
Oklahoma	832	4,851	1,218	6,901	24	200	9.8	81.2
Pennsylvania	4,915	14,788	8,172	27,875	40	227	12.7	72.3
Texas	5,625	20,740	7,345	33,710	27	162	12.8	76.8

Note: Bioscience Research consists of research-oriented life science, medical, and agricultural fields; Bioscience Support fields complement bioscience, including computer science, chemistry, environmental studies, and zoology; Clinical fields are oriented toward medical and other professional practitioners.

Note: Because bioscience degrees are for each state proper, the employment used to calculate degrees per 1,000 bioscience employment for Missouri is for the state of Missouri only, without the metropolitan portions of St. Louis and Kansas City that are located in Illinois and Kansas.

Sources: National Center for Education Statistics, COOL (College Opportunities On-Line) data; Dun & Bradstreet MarketPlace (employment level); United States Census Bureau (population), Battelle calculations.

Figure 17: Bioscience Degrees Awarded, All Levels, 1999-2000 Academic Year



Source: National Center for Education Statistics

Note: The Kansas portion of the Kansas City SMSA and the Illinois portion of the St. Louis SMSA are not included in the Missouri data because the data are reported on a state basis.

One beneficial side effect of any state-level R&D initiative is the creation of a local pool of highly trained professional bioscience talent. However, employers in the bioscience sector also need less-specialized labor, including college graduates who are well informed on bioscience issues but not themselves researchers, and associate-level or certificate-trained high school graduates who can fill laboratory technician roles. Of the benchmark states, several stand out as having created initiatives focused exclusively on filling the educational pipeline with students whose skills will be relevant to the bioscience sector.

For example, education and training have for many years been a fully recognized and funded program area of the NCBC, which has aggressively developed and promoted bioscience-friendly curricula at the secondary and postsecondary levels. In Maryland, while the state has not supported academic curricula (as it has in IT), there has been strong support for postsecondary technician training, resulting in creation of a specialty organization called the Biotechnical Institute of Maryland.

Another important workforce need, particularly for firms that are transitioning rapidly into production environments or that are recruited from other states, is the retraining of in-place workforce. Maryland now recognizes bioscience fields as one component among many in their programs for employer-customized training. In general, the community colleges situated in those communities, that already have a bioscience base take the lead in providing services to this sector.

Finally, a critical need for the bioscience sector is entrepreneurial management talent. North Carolina addresses this need by providing mentoring service through the nonprofit Council for Entrepreneurial Development at Research Triangle, and the University of Maryland’s Dingman Center for Entrepreneurship performs an analogous function in that state.

Missouri’s proposed Mathematics Academy is an initiative that can contribute to training students for careers in the life sciences. In addition, Missouri has given priority in mission enhancement funds for the University of Missouri System and in discretionary funding for community colleges to address some curriculum changes and program development for the life sciences.

Summary

Missouri’s R&D base remains less developed than those of the benchmark states; however, it is growing faster than the majority of the benchmark states. In particular, Missouri is experiencing rapid growth in NIH funding. Missouri lags the benchmark states but is making progress in building the state’s life science venture capital market.

The benchmarking analysis also shows that other states have been more aggressive in investing in R&D infrastructure, creating and supporting programs to encourage and facilitate technology transfer and commercialization, and providing assistance to new and expanding life science companies. To compete with the states seeking to become leading life science centers as well as with those that have established centers, Missouri will have to increase its commitment to investing in its research infrastructure and providing greater support for the establishment and growth of life science companies.

Situational Analysis

This section presents an analysis of the strengths, weaknesses, opportunities, and threats facing the region in building a life science sector for the future. This analysis is based on numerous interviews conducted with leaders from industry, academia, government, and technology intermediaries, in addition to data analysis conducted earlier. This SWOT analysis is much like a business planning process. In preparing its business plan, a company undertakes a similar exercise, identifying its internal strengths and weaknesses and taking into account and addressing external factors, including markets and opportunities and adverse events and threats. In the following review, Missouri’s life science base is examined much as a business would examine itself.

STRENGTHS

Missouri has a fast growing and sizable life science research base that will increasingly predominate in the future, with two new world-class nonprofits and the greater focus on research activities across the university sector.

Life sciences dominate university research efforts in Missouri. With more than 80 percent of its university research funding going toward life science research, only one other state outpaces Missouri. Nationally, the average is approximately 57 percent. Between FY 1995 and FY 2000, life science R&D funding to Missouri universities totaled more than \$2 billion.

This base of life science research will increase significantly as a result of the establishment of two major nonprofit research institutions destined to join the ranks of world-class, nonprofit life science research institutes—the Donald Danforth Plant Science Center and the Stowers Institute for Medical Research. It is expected that these two institutions together will add in excess of \$100 million in annual life science research to Missouri.

In addition, universities in all regions of Missouri are placing a major emphasis on life science research. All campuses of the University of Missouri are actively investing in the growth of their life science research efforts. The University of Missouri-Columbia is building a 124,000-square-foot life science center that will house 50 new research laboratories, controlled growth facilities, teaching and computer labs, and a 250-seat auditorium. In addition, the University of Missouri-Kansas City’s plan for a new Health Sciences Building will be state of the art, and the University of Kansas and Saint Louis University also are firmly committed to and focused on growing their life science research base. Washington University, which has served as the predominant life science research academic anchor for St. Louis and the state, continues to build its base and stature as well.

Missouri has a broad distribution of educational, medical center, and agricultural bioprocessing capabilities on which to build the state’s life science future.

Along with the growth in basic research, Missouri continues to advance its position in clinical and applied research, which is the foundation for translating basic research discoveries into new medical treatments, agricultural products, and environmental services and products. Examples of the state’s clinical strengths include

- Kansas City, through its extensive network of hospitals, is also a leading center for clinical research, especially in cardiovascular, stroke, and pediatric diseases.
- Washington University has strong clinical research strengths, having an NIH-funded General Clinical Research Center to facilitate and support patient-oriented research, along with a Center for Clinical Studies to support the evaluation of new pharmaceuticals and medical devices. The recent designation of the Siteman Cancer Center as a National Cancer Institute (NCI)-supported cancer center will further increase the clinical research capabilities at Washington University in a fast-moving area of biomedical research.
- Saint Louis University also has a strong focus on clinical research, especially in the area of vaccine evaluations.
- The University of Missouri with its extensive farm system, along with other experimental agricultural facilities at nonresearch universities in Missouri, offers a tremendous test-bed facility for new advances in the plant sciences.
- Fort Leonard Wood is a major testing center for new environmental technologies.

Missouri has several private sector and nonprofit firms that serve as life science anchors.

The Midwest Research Institute in Kansas City is an internationally recognized center for applied research and technology development, with expertise in areas ranging from environmental and cancer research to cutting-edge work in drug development. MRI recently led a team of Kansas City research institutions in developing and submitting a proposal to the National Institute for Environmental Health Services for a multimillion-dollar proteomics consortium.

Missouri also has leading firms in the food, nutrition, and agricultural chemical sectors, including Purina Mills, Kraft, Conopco, Dairy Farmers of America, Archer Daniels, Midland, Protein Technologies, Monsanto, Chemsico, and Bayer. These leading firms provide excellent opportunities for partnering and accessing markets, and also are key research generators. Plant science companies also are emerging in Missouri, such as Orion Genomics, which recently received a five-year, \$7.5 million matching grant from the U.S. Department of Energy with NC+ Hybrids and SolviGen to improve sorghum as a source of bioproducts. Orion will focus on sequencing the genome and identifying valuable traits.

Missouri also has significant contract research and biological supply companies, led by Sigma-Aldrich, Quintiles, Pharmaceutical Research Associates, and ABC Laboratories.

Community leadership and support have emerged in the state’s two largest regions as a result of undertaking life science strategies, in addition to niche strategies that have developed in the smaller regions.

The St. Louis Regional Chamber and Growth Association (RCGA), in concert with Civic Progress and the Coalition for Plant and Life Sciences, is implementing a strategy to position

St. Louis as the international center for the plant sciences and a major international center for the life sciences. Kansas City also has initiated and completed their regional life science strategy. The Kansas City Area Life Sciences Institute is a not-for-profit corporation established to implement a strategy to foster collaboration and resource sharing between the area’s private sector, academia, and government.

Other regions of Missouri also offer opportunities in the life sciences. For example, the St. Joseph area is becoming a center for the animal sciences. Leading firms in St. Joseph include the headquarters of Boehringer Ingelheim Vetmedica, part of Boehringer Ingelheim of Germany; Phoenix Scientific, an independent manufacturer of generic pharmaceuticals for the animal health industry; Friskies PetCare and Friskies Product Technology Center; and Omnium LLC, a 50/50 venture between Terra Industries and Farmland Industries that formulates crop protection products. Cape Girardeau is emphasizing field trials and new varieties of rice and other agricultural crops. Kirksville, with its higher education and medical presence, is similarly developing a focus in the life sciences, as is Joplin. In many of these cases, a key anchor is one or more state colleges and universities as well as community colleges. These regions contribute a significant share of the future workforce for both the St. Louis and Kansas City metropolitan regions, as well as offer opportunities in bioprocessing manufacturing, medical care, and treatment.

Missouri’s strengths in information technology can serve as an enabling technology and supplier industry to the life sciences.

Strong life science regions require strong information technology industry bases as well. Advances in information technology have brought powerful computational capabilities to biologists’ laboratories, allowing them to store and manipulate very large scale data sets. With the mapping of the human genome, life science companies increasingly depend on the tools and techniques of bioinformatics to further research and product development.

While most of the activity in bioinformatics is clustered within the major life science research centers of the United States (e.g., Boston, San Diego, suburban Maryland, and North Carolina’s Research Triangle), several Missouri firms are active in the bioinformatics arena. These include Cerner, Tripos, and Express Scripts, among others. Missouri’s bioinformatics sector is continuing to develop as many of the state’s bioinformatics companies either have been formed or have witnessed startling growth since 1995.

Missouri is centrally located in the nation’s agricultural heartland, providing easy access to markets important to the life sciences in addition to its access to waterways for export opportunities.

Missouri is located at the heart of the United States, within 500 miles of 43 percent of U.S. population and households. The state has the seventh largest highway system in the nation, two major rivers with more than 1,000 miles of navigable waterways, and the service of two international airports. Missouri also has the second and third largest railroad terminals in the nation.

Missouri has a good quality of life and a low cost of living.

In interviews with the Battelle team, company executives mentioned that it is easy to retain workers because of Missouri’s high quality of life and low cost of living. While company executives acknowledged that it may be a challenge to interest researchers and skilled technical

workers in relocating to Missouri, it is not difficult to convince prospective recruits to relocate to the state once they visit, nor is it difficult to retain workers. One attraction is Missouri’s low cost of living, which, at 94.3 percent of the U.S. average, is the third lowest in the nation.

A strong trade association for the life sciences has emerged.

The presence of networking organizations is a hallmark of leading centers of the life sciences. Such organizations serve as educators, advocates, and clearinghouses for information on the growing life science base in their states and regions and work to assist their life science base to be competitive and to expand. The Missouri Biotechnology Association (MOBIO) was created for this purpose. MOBIO is a statewide membership organization that provides a legislative focus, education initiatives, and networking opportunities for the biotechnology/life science industry in Missouri.

WEAKNESSES

Except for Washington University, the state’s life science research base has experienced underinvestment and consequently is not fully developed.

Missouri has a strong research base in the life sciences primarily because of the presence of Washington University. In FY 2000, Missouri ranked 12th in NIH awards with total funding of \$367 million. Of this amount, however, more than 75 percent went to Washington University. Missouri’s other universities received only \$87.5 million in NIH funding in FY 2000. Excluding Washington University, Missouri would rank 29th among the states in NIH funds, showing that the state has underinvested in basic research.

The universities’ ability to compete successfully for research funding depends to an extent on their abilities to attract world-class faculty and to provide the laboratories and state-of-the-art equipment to conduct cutting-edge research. Yet, Missouri has not invested sufficiently in building the universities’ research capabilities. Missouri’s facility funding, for example, suffers from having only one-year budgets that get reprioritized each year and provide less than full funding for facilities, which causes delays in completing projects.

Missouri’s universities have few resources dedicated to technology transfer and commercialization, and the interface with industry clients is weak.

While Washington University has been very effective in terms of licensing technology and has had some success in spinning off new start-up companies, other Missouri institutions have been less successful in their technology transfer efforts. Between FY 1996 and 1999, Washington University executed 2.03 licenses per \$10 million of R&D expenditures and spun off nine start-up companies. During the same time period, the University of Missouri System executed 0.95 patents per \$10 million of R&D expenditures and spun off one start-up company.

Interviews with business executives indicated that Missouri companies are not partnering with Missouri’s research institutions to the extent that they might and that the state has provided limited staffing and dedicated resources to support commercialization activities or to encourage greater interaction between university researchers and industry.

The state’s private sector base, while having several major anchors, is not strong in emerging life science fields.

As shown in the economic analysis, the drug and pharmaceutical subsector, a traditional strength in Missouri, declined in employment in the state by 28.7 percent between 1995 and 2001 while growing nationally by 39 percent. The research and testing subsector—a key life science subsector reflecting emerging and innovative biotechnology companies—did not keep pace with national growth rates. Thus, despite gains in employment and establishments, Missouri continues to lose ground to the nation in these key subsectors.

The public sector is not sufficiently focused to foster its life science resources, and the state lacks a systematic “tool kit” of assistance to attract firms and encourage their growth.

Missouri currently uses tax credits as its key economic development tool, not just for promoting growth of technology industries, but across all areas of economic development. In contrast, other states offer a comprehensive array of programs and services to support the creation and growth of technology businesses. In addition, those states seeking to foster the growth of the life sciences offer initiatives that address the specific needs of biotechnology companies, including providing access to seed and early-stage capital, subsidizing the cost of life science facilities, and providing in-depth planning and management assistance to entrepreneurs and start-up companies. To compete successfully, Missouri needs to develop policies and programs that will meet the needs of life science companies at all stages of their development.

The state’s financial markets are not sufficiently developed to encourage private sector venture investments in the life sciences (although St. Louis has achieved some recent success), and significant gaps exist in pre-seed/seed, angel, and later-stage investing for the life sciences.

Between 1995 and 2001, \$146.7 million was invested in Missouri life science companies. More than half of this investment was made during the 2000–2001 time period. In 2001, Missouri life science companies received \$42 million in venture capital. In comparison, life science companies in Pennsylvania, North Carolina, and Maryland received venture capital investments of \$171 million, \$158 million, and \$127 million, respectively, in 2001.

Missouri also differs from these states in the distribution of venture capital investments by sector. Of the total dollars invested between 1995 and 2001, 55 percent of the funds went to medical device and equipment companies and 20 percent was invested in biopharmaceutical companies. Maryland life science venture capital investments, in comparison, are heavily focused on the biopharmaceutical sector, while Pennsylvania has significant levels of investment in both biopharmaceuticals and medical software and information. While life science venture capital investments are increasing, Missouri still lacks lead venture capital firms for life science investments.

Many life science companies need less than \$200,000 as pre-seed investments and in the range of \$250,000 to \$2 million as seed investments, but have difficulty securing them in Missouri. Initial steps have been taken to address the need for seed capital, but these are at an early stage. In 1999, the legislature passed the New Enterprise Creation Act authorizing \$20 million in state tax credits to attract funding for early-stage technology businesses. Taking advantage of these tax credits, St. Louis-based Prolog Ventures has launched a \$33 million fund that will invest in

early-stage life science and information technology companies. In addition, more than \$150 million has been raised by three funds located in Missouri to make investments in the life sciences as a result of St. Louis’s efforts to implement its plant and life sciences strategy. While these are all steps in the right direction, Missouri will need to do more to attract all stages of capital investment.

The state is facing severe budget constraints that will make it difficult to invest at the level required to position Missouri as a strong competitor in the life sciences.

In FY 2002, Missouri was forced to cut \$750 million from its enacted FY 2002 budget.⁴ This was the sixth largest budget cut among the 50 states in a year in which states faced serious fiscal crises. The only states that made larger budget cuts were California, New Jersey, Oregon, North Carolina, and Georgia. For FY 2003, Missouri is facing a budget deficit of approximately half a billion dollars. Governor Holden has proposed \$612 million in cuts in the state’s General Revenue core funds, with \$133 million of the total made up from the state’s rainy day fund.⁵ The Governor is supporting legislation that would allow Missouri to securitize the state’s tobacco settlement to access additional resources at this time. For FY 2003, the Missouri Department of Higher Education requested \$1.3 billion in funding. The Governor has recommended \$1.1 billion in funding.

Missouri is facing one of its most difficult fiscal and budget crises in more than a decade. This crisis will make it difficult for the state to stay competitive with or exceed other states positioning themselves in the life sciences. States such as Ohio and Louisiana are giving priority to long-term investments in the life sciences, even in difficult budget times, in recognition of the long-term impact such investments will have on their future economy.

There is insufficient wet-lab space for firms to start up, expand, and grow.

The availability of specialized lab space needed by life science companies has been a concern across Missouri. In St. Louis, a study completed in October 2001 documented an expected need within the next three years for 252,200 square feet of lab space, including 138,500 square feet of wet-lab space, based on information provided by 24 existing life science companies. Similarly, recent focus group meetings with Missouri industry have identified specialized lab space as a key life science development issue across the state.

Barriers and silos within and among Missouri’s institutions and organizations may be the state’s undoing in positioning itself in the life sciences.

Efforts are underway in the state’s major metropolitan areas to better link their various research institutions and companies. The Kansas City Area Life Science Institute and St. Louis’s Plant and Life Science Coalition are designed to foster greater collaboration in their respective regions. But, too many silos still remain across industry, higher education, and the public and nonprofit sectors in the life sciences. In the past, “distributive equity” has driven the state’s investments, and urban/rural divisions thwart efforts to move the state forward. There is limited connectivity among the state’s regions. For Missouri’s life science initiative to succeed, it must leverage the

⁴ National Governors’ Association and National Association of State Budget Offices, *Fiscal Survey of the States*, November 2002.

⁵ *The Missouri Budget: FY 2003 Budget Summary*, www.oa.state.mo.us/bp/budg2003/.

capacities of all of the state’s leading institutions and encourage alliances among and between regions.

OPPORTUNITIES

The newly established Donald Danforth Plant Science Center and Stowers Institute for Medical Research can help uniquely position Missouri and build the state’s image as a life science center.

Both the Donald Danforth Plant Science Center and Stowers Institute for Medical Research are truly unique institutions that provide an opportunity to put Missouri on the map in terms of the life sciences. The Donald Danforth Plant Science Center is an innovative partnership joining the Missouri Botanical Garden, Monsanto Company, Purdue University, the University of Illinois at Urbana-Champaign, the University of Missouri-Columbia, and Washington University in St. Louis. Established in 1998, the Center aims to become the premier research center dedicated to plant sciences. The Stowers Institute for Medical Research in Kansas City is committed to becoming one of the most innovative biomedical research facilities in the world. The current endowment of the institute is \$1.6 billion. It is estimated that these two research centers will employ approximately 500 researchers and add \$100 million annually to Missouri’s R&D base.

The establishment of these emerging world-class centers offers significant opportunities for increasing the research capabilities of other research institutions in Missouri, attracting world-class researchers, and commercializing research discoveries.

Federal funding for life science R&D is expanding dramatically. Missouri has an opportunity to capture a significant share of this R&D and must continue to do so if its research institutions are to play major roles as research engines of Missouri’s future economy.

The NIH budget has doubled over the last five years. The President’s FY 2003 budget requests \$27.3 billion for NIH, an increase of \$3.7 billion over FY 2002, the largest one-year increase ever. In FY 1998, the NIH budget was \$13.6 billion. These dramatic increases in federal life science R&D funding provides the opportunity for those institutions that are well positioned to compete for R&D funding to greatly increase their NIH awards—the “gold standard” in academic research funding.

Capturing a percentage of this increase in federal life science R&D funding would enable Missouri to move into the top tier of life science states; but, in order to compete, the state’s universities and research institutions need state-of-the-art instrumentation and laboratories to conduct the research and to attract the quality of researchers and faculty that compete successfully for NIH funding.

There is an opportunity to build on regional strategies across the state and to facilitate connections across regions.

St. Louis adopted a Plant and Life Sciences Strategy in 2000 and has proceeded rapidly with implementation. The region has initiated an aggressive BioBelt marketing campaign, and progress has been made on attracting life science investment funds to the region. In Kansas City, the Kansas City Area Life Science Institute has been created to attract research funding by

encouraging collaboration among the region’s universities, research institutions, and hospitals. Similar efforts are underway elsewhere in the state. For example, in St. Joseph, the St. Joseph Area Chamber of Commerce, in cooperation with Missouri Western State College (MWSC) and Heartland Health has formed a Life Sciences Network to bring existing life science industries, MWSC, and Heartland together to cultivate the region’s existing life science sector and to develop strategies to grow the life science industry in the future.

There is an opportunity to build the state’s environmental life science sector by capitalizing on the presence of Fort Leonard Wood and other Missouri institutions, such as the Midwest Research Institute, that are active in environmental life sciences.

Environmental life sciences refer to the application of life science for environmental purposes. Environmental life sciences cover a wide range of life science applications, from the biochemical analysis of water, air, soil, and waste products to the design of pesticides and herbicides, from food contamination testing to the genetic construction of microbes for use in environmental remediation. Numerous Missouri firms are active in environmental life sciences, including ABC Laboratories, Environmetrics, and the Midwest Research Institute. MRI utilizes its engineering and analytical chemistry capabilities to assist municipalities and industrial and agricultural firms to address containment, treatment, and remediation problems; pollution-free manufacturing; and emission monitoring and control. Other environmental research centers include Washington University’s Center of Air Pollution Impact and Trend Analysis and KUMC’s Center for Environmental and Occupational Health.

Fort Leonard Wood is home to the Army’s Environmental and Chemical Schools, which train Army personnel to carry out assignments involving environmental and chemical activities such as dealing with hazardous materials, bioremediation, and first response teams. Recently, Fort Leonard Wood was designated as the Army’s Environmental Integration Command, which is responsible for setting out the doctrine, training, and organizational approaches on environmental issues for the Army. With the increased emphasis being placed on bioterrorism and homeland security, activities at Fort Leonard Wood are likely to increase, offering additional opportunities for nurturing the development of an environmental life science sector in Missouri.

THREATS

Other states are investing more and for longer periods of time in the life sciences, and Missouri’s financial constraints make it hard to catch up.

States such as Michigan, North Carolina, Maryland, and Pennsylvania are investing aggressively in a comprehensive range of programs designed to create university-industry partnerships in the biosciences and to assist start-up and growing bioscience companies. Other states, such as Georgia and Ohio, are aggressively pursuing life science development strategies, including strengthening research, increasing university-industry collaborations, and beefing up their business development support. Missouri will have to invest significant resources in the life sciences just to keep even with these states, let alone surpass their efforts.

Failure to capitalize on the opportunities the tobacco settlement provides could strike a fatal blow to developing Missouri’s life science sector.

Unlike some of these states, which have enacted legislation dedicating a portion of their tobacco settlement funds on a permanent basis, Missouri failed to pass a bill that would have dedicated a specific percentage of Missouri’s tobacco settlement funds to the life sciences permanently. Using a portion of the state’s tobacco settlement dollars or other funding source is critical in Missouri, given the state’s fiscal situation and limitations on the state’s ability to raise revenues.

Missouri’s multistate base can be an impediment to achieving consensus and action, and adds complexity to implementation.

Missouri is in a unique situation—its major metropolitan areas are located on a state border where parts of the area fall into either Illinois or Kansas. Indeed, Missouri is bordered by eight states, providing opportunities for broad regional cooperation but requiring an extraordinary degree of logistical coordination and linkage. While this situation can provide additional support from additional legislative representatives, it can also make it difficult to achieve support for, let alone implement, state-funded initiatives.

The state’s risk-averse culture and lack of knowledge and understanding of the life science industry could constrain action.

Missouri is a conservative state in which state government has not played an activist role in terms of promoting technology-based economic development. In addition, the general public does not appear to understand the nature of the life science industry and how its growth will benefit the citizens of Missouri. These attitudes will put Missouri at a disadvantage in competing with other states in which local leaders and citizens truly understand the potential that the life sciences can hold for both their citizens and their future economic growth.

SUMMARY

Missouri has a number of strengths for positioning itself as a life science-driven economy, but the state also has a number of weaknesses that must be addressed if Missouri is to achieve its goal of becoming a center of the life sciences. First and foremost, Missouri must continue to build its research capacity in the life sciences, investing in its research institutions to enable them to compete for a greater share of life science R&D funding. Second, as the research base grows, emphasis should be placed on encouraging technology commercialization and fostering the growth of new life science companies. Third, Missouri must attract new life science companies, help existing companies to grow and capitalize on its strong industry anchors, which include Monsanto, Bayer, Midwest Research Institute, Phoenix, and others.

Most urgently, Missouri must be proactive, leaving no doubt of the state’s commitment to the life sciences. The actions and efforts undertaken during the next decade likely will decide Missouri’s future position in the life sciences.

The challenge of growing the life sciences cluster in Missouri comes at a difficult time of recession. The easiest course, in the short term, would be to hunker down, to play it safe, to rely on the funding of basic services to get the state by, and to postpone bold initiatives until things look better. However, unless significant new state and other dollars are provided, it will be

extremely difficult for Missouri to remain competitive with other states vying to become life science leaders.

Missouri can look to the North to see how a sustained investment strategy can pay off. Faced with the decline of manufacturing and the growth of information technology in the late 1970s and the early 1980s, states like Pennsylvania, Ohio and Michigan saw their factories close and their young people leave for California, Washington, and other states investing in the technology revolution. With focused investments, these northern “rust-belt” states can today point to real strengths in the life sciences, and a continued commitment not to be left behind in the biotechnology revolution. They already have drawn their line in the sand and begun investing for the future.

The next section of this report presents a vision of what Missouri’s life science sector could become if strategic investments in the state’s future are made. It is followed by proposed strategies and actions to address the weaknesses identified, to build on Missouri’s life science strengths, and to capitalize on the opportunities presented.

Missouri’s Life Science Strategies and Actions

The opportunity to further develop the life science cluster is a significant one for Missouri. At a time when other traditional industry clusters face stiff competitive challenges, the life sciences are a major cluster of industries in which the technological superiority found in the United States can sustain economic advantage and growth for years to come. The benefits of the life sciences can be far reaching. Life sciences include many industries—from manufacturing, agriculture, services, and research—offering a broad range of employment opportunities and generating higher average earnings for workers than generally found across the nation. Regions of the nation that can successfully enhance its life science cluster gain a key anchor for generating significant growth and prosperity in the years ahead.

This report has noted the size and characteristics of Missouri’s life science research and industry sectors and has identified specific areas of core competencies in the life sciences. Missouri also has been benchmarked against both accomplished life science leaders and those that aspire to such status. And, finally, Missouri’s strengths, weaknesses, threats, and opportunities in the life sciences have been analyzed. Based on this comprehensive review and analysis, this section of the report lays out the vision and mission for Missouri life sciences, the major strategies needed to accomplish that mission, and the key actions needed to realize these strategies.

VISION AND MISSION

The future vision for the life sciences is bold and far-reaching, yet achievable. This vision can take Missouri into the next decade:

Missouri will be a leading Midwest life science center, among the nation’s and world’s leaders, in plant, animal, and human health, recognized for its world-class research and exceptional ability to commercialize research discoveries into new products and services.

Missouri will be home to leading-edge researchers and leading-edge firms whose discoveries and products contribute to both a healthy citizenry and a healthy economy, driven by the state’s life science base.

To achieve this vision, the following mission is proposed:

Missouri will invest from many sources (state, federal, philanthropic, industry) to enhance its research base through private/public partnerships to ensure world-class leadership in core research fields. Missouri also will encourage collaboration among and between its research institutions, industry, and established value-added intermediary organizations. Technology commercialization efforts will be enhanced and expanded so as to increase the rate of commercial application from research, resulting in significant growth in firms, jobs, and wealth for the state and its citizens.

STRATEGIC APPROACH

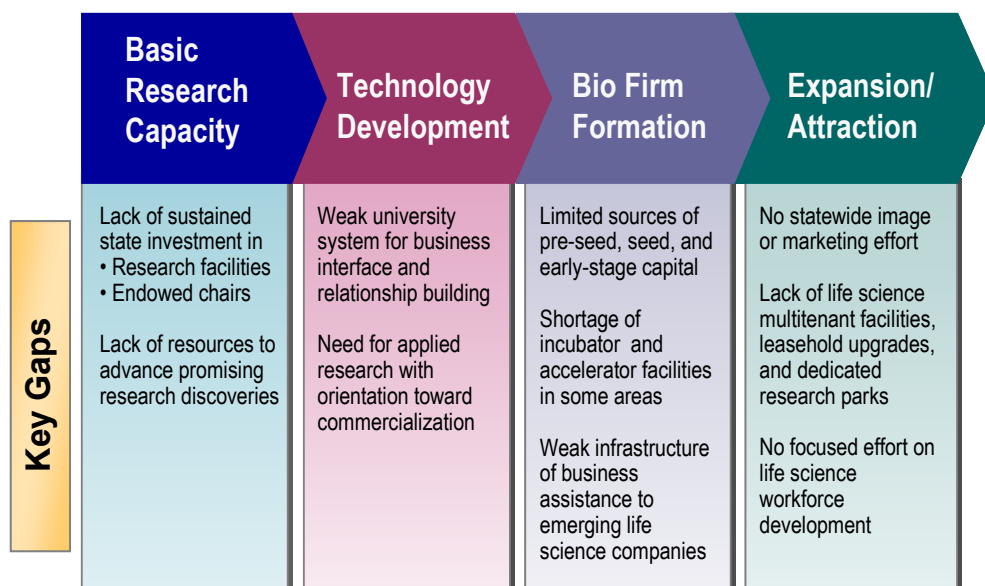
There is no single, one-size-fits-all approach to realizing Missouri’s promise and vision as a leading center in the life sciences. Missouri must recognize the differentiated needs of its respective regions and build on regional strengths and niches. Specifically,

- Kansas City must further build its research base and develop stronger technology commercialization capacity over time, while continuing to support its existing life science industry anchors.
- St. Louis brings a unique specialization in plant science across research and industry drivers, along with great strength in biomedical research. It is a region that must aggressively build industry connections and encourage technology commercialization, while further enhancing its research base in plant as well as life sciences.
- Rolla-Fort Leonard Wood must strengthen the connections and depth of its niches in environmental sciences and homeland security with industry and higher education.
- St. Joseph should continue to build on and grow its base of animal science companies.
- The state’s smaller and more rural regions can play a significant role both in addressing workforce needs as well as undertaking field experiments, testing, and applications development through better linkages to the industrial, institutional, and organizational infrastructure found in the state’s metro areas.

One important element to guide Missouri is a comprehensive approach to *filling the gaps* that exist across the continuum of research, commercialization, new firm formation, and industry growth and expansion. This gap-filling approach can serve to complement and augment the significant regional efforts underway across Missouri in the life sciences, particularly advancing key investments. Figure 18 sets out the key gap-filling needs found in Missouri.

But, focusing on gap-filling initiatives alone will not be sufficient to make Missouri a world-class leader in areas of life science. Missouri must create an environment that promotes

Figure 18: Missouri’s Key Gaps Along the Life Science Development Continuum



innovation, supports the commercialization of research discoveries, and encourages linkages between industry and academic researchers. Collaborations are key for Missouri to move beyond the silos found in academia and industry and across regions.

The life sciences already have begun to serve as a unifying force among rural parts of Missouri and the two major metropolitan areas—St. Louis and Kansas City—which both have made a key strategic focus for their regional future and are working jointly to build this sector for the state. In other words, the life sciences are a cornerstone for “**One Missouri**,” one vision around which Missouri can build a healthy and safe citizenry, as well as a strong, competitive economy.

The strategy, *Life Sciences & Missouri’s Economic Future: An Opportunity to Build “One Missouri,”* is a three-prong approach to promote technology-based development in the state through increasing research capacity, aggressively implementing economic development initiatives, and striving to improve the technical aptitude of the state’s workforce.

Missouri has the opportunity today to develop a world-class life science sector for the future. However, to become a leading life science center will require that Missouri focus its efforts, investments, and initiatives in three key areas:

- Building life science research capacity;
- Supporting the development of a critical mass of life science companies; and,
- Developing the supply chain of talent that will enable the life science sector in Missouri to grow and succeed.

Under the rubric of these three areas of emphasis, Battelle proposes four strategies, encompassing 20 actions detailed in the full report, to achieve Missouri’s Bioscience Vision for the future.

- **Strategy One:** *Enhance the capacity of the state’s higher education and research institutions to undertake, in collaboration with industry, world-class research in areas of core competency.*
- **Strategy Two:** *Create a critical mass of life science companies by focusing on commercialization and access to capital for new firm creation, expansion, and recruitment.*
- **Strategy Three:** *Create a supportive business, tax, and regulatory climate for life science companies, and a national and international image as a leading center in the life sciences.*
- **Strategy Four:** *Increase the connectivity between life science employers and educators and encourage students and workers to pursue careers and opportunities in the life sciences.*

These four strategies, and the proposed 20 actions they encompass, are outlined in Figure 19 and Table 6, followed by narrative detail in the ensuing pages. It is anticipated that these strategies and actions would be implemented over a five-year time period. *Immediate* priorities should be undertaken as soon as possible, *short-term* priorities should be undertaken in one to three years, and *mid-term* priorities should be implemented in the three- to five-year time frame.

Figure 19: Proposed Actions to Address Key Gaps Along the Life Science Development Continuum

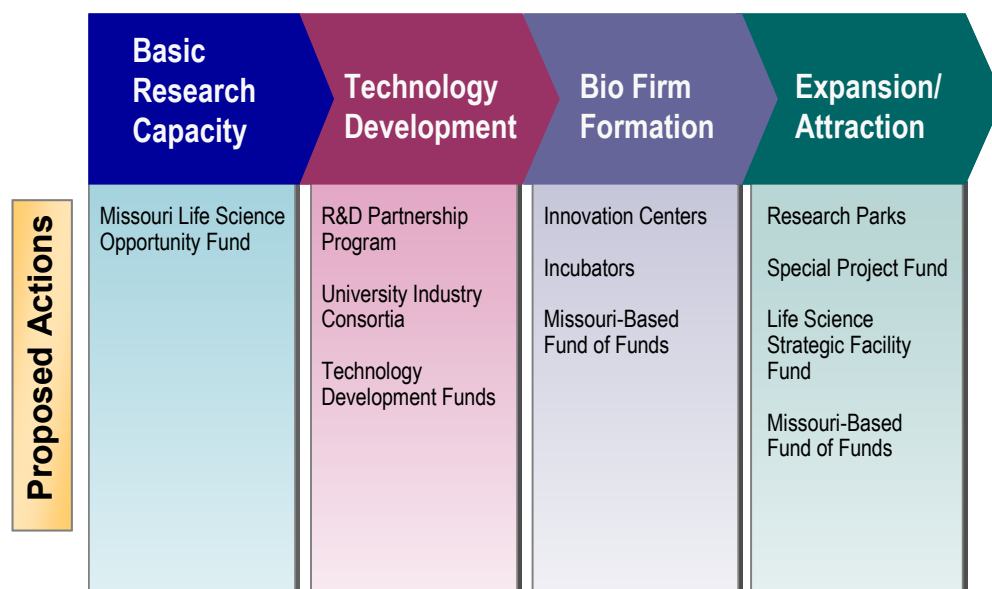


Table 6: Proposed Strategies and Actions for the Life Sciences in Missouri

Strategy	Action	Priority
Strategy One Enhance the capacity of the state's higher education and research institutions to undertake, in collaboration with industry, world-class research in areas of core competency.	Release funding and eliminate matching requirements for legislatively approved capital projects of the University of Missouri System that build capacity in the life sciences and related fields.	Immediate
	Create a Missouri Life Science Opportunity Fund that would invest in higher education and nonprofit research facilities, faculty/endowed chairs, and life science equipment.	Immediate
	Establish an R&D Partnership Program to encourage collaborations between the state's higher education and research institutions and industry.	Mid-Term
	Provide funding to universities and research institutions to form joint consortia with industry clusters to pursue joint ventures and major funding opportunities.	Mid-Term
	Work with Missouri's and neighboring states' Congressional Delegations to secure federal funds and projects that further build the state's life science base in both its higher education and nonprofit research organizations and industry.	Mid-Term

Table 6: Proposed Strategies and Actions for the Life Sciences in Missouri (continued)

Strategy	Action	Priority
Strategy Two Create a critical mass of life science companies by focusing on commercialization and access to capital for new firm creation, expansion, and recruitment.	Revise and expand the mission of the Innovation Centers to provide in-depth assistance to technology entrepreneurs and make their services available statewide by establishing satellite operations in the second-tier metropolitan areas to enable these areas and rural parts of Missouri to obtain assistance.	Immediate
	Establish new and expand existing life science wet-lab incubators and accelerators throughout the state in areas with potential to develop firms in niche markets, including field test centers.	Short-Term
	Create and invest (through appropriations or tax credits) in Technology Development Funds that would operate through appropriate third-party mechanisms in each major region of the state to undertake prototype development and other efforts to commercialize technology.	Immediate
	Review university policies and practices (distribution of royalties, disclosures, etc.) and revise as necessary to encourage and provide incentives to faculty to commercialize their technology through spin-offs or licensing to industry, particularly in Missouri. Secure additional staffing and expand functions (market assessments, equity participation, accessing capital) in the state’s public and private universities’ technology transfer, commercialization, and industrial liaison functions.	Short-Term
Strategy Three Create a supportive business, tax, and regulatory climate for life science companies, and a national and international image as a leading center in the life sciences.	Create a large-scale (\$150 million to \$200 million), Missouri-based “fund of funds” to serve as a vehicle for institutional investment of all kinds in private equity funds that in turn invest in life science start-ups and in the real estate necessary to house them. Encourage Missouri’s public pension fund boards to allocate a small portion of their pension assets to this fund.	Immediate
	Pursue a comprehensive approach to address life science companies’ specialized facility requirements, including establishing a life science strategic facility investment fund that will provide financing for leasehold improvements and multitenant life science facilities, and providing state support for research park development.	Mid-Term
	Make changes in Missouri’s tax structure to provide incentives for the growth and development of the state’s bio-science base, including changes in the R&D and sales and use taxes as well as an overall comprehensive review and assessment of the state’s tax structure.	Immediate
	Establish a Life Science Special Project Fund through MTC for large-scale, nonuniversity projects to retain, attract, and expand firms in the state.	Mid-Term

Table 6: Proposed Strategies and Actions for the Life Sciences in Missouri (continued)

Strategy	Action	Priority
	Develop a statewide image, marketing, and business development effort that builds on and supports current regional efforts to market Missouri as a center for the life sciences.	Immediate
	Initiate a statewide education campaign on the benefits and importance of the life sciences to the state’s economic future.	Mid-Term
Strategy Four Increase the connectivity between life science employers and educators and encourage students and workers to pursue careers and opportunities in the life sciences.	Improve math and science education at the K-12 level by exploring innovative methods to promote excellence, thereby increasing opportunities for students in the life sciences.	Short-Term
	Provide incentives to higher education institutions to work with industry to review and adopt new multidisciplinary curricula, including offering related degrees and certificates, and provide innovative workforce programs in the life sciences.	Immediate
	Initiate a yearly workforce survey through MOBIO of the state’s life science industry to assess demand for various skills, positions, and careers and convey this information to education and workforce providers.	Immediate
	Offer year-round internships and co-op opportunities to higher education students in firms, nonprofits, and other life science organizations as well as summer opportunities for residents going outside the state for their education.	Mid-Term
	Support, market, and expand the Advantage Missouri Program, the state’s scholarship program that includes students majoring in the life sciences, for individuals that stay in the state upon graduation.	Mid-Term

STRATEGY ONE: ENHANCE THE CAPACITY OF THE STATE’S HIGHER EDUCATION AND RESEARCH INSTITUTIONS TO UNDERTAKE, IN COLLABORATION WITH INDUSTRY, WORLD-CLASS RESEARCH IN AREAS OF CORE COMPETENCY.

To become a major life science center, a state must have a world-class higher education presence, with leading-edge researchers and clinicians in the medical, life, and biological sciences. Medical centers and teaching hospitals, multidisciplinary centers, and modern facilities, well-equipped for research, with leading researchers, are hallmarks of a respected regional and state life science center today. Generally, it is rare to have a cluster of life science firms without a correspondingly strong set of higher education and national laboratories nearby, as demonstrated in Silicon Valley, Boston, Research Triangle Park, Maryland, Alabama, and Philadelphia.

The establishment of the Stowers Institute for Medical Research in Kansas City and the Donald Danforth Plant Science Center in St. Louis provides an opportunity to build Missouri’s world-class R&D stature in key life science areas. These nonprofit vehicles working collaboratively with the state’s higher education institutions have the potential to match the R&D capabilities of other established life science centers.

As discussed previously, although Missouri’s research base is heavily concentrated in the life sciences, Missouri currently stands in the second tier of states in terms of overall life science research. For Missouri to compete with existing and emerging life science centers, it must seek to capture a greater share of the nation’s life science R&D budget. To do this will require the state to support its research institutions in their efforts to expand their life science R&D activities by funding core research facilities and providing resources to recruit and retain world-class faculty and researchers. In addition, Missouri should invest in its areas of core competency, which include bioinformatics, proteomics, bioengineering, and drug design and development. The related areas of information technology and engineering also need to be strengthened.

To build a strong life science-driven state economy, Missouri also should seek to increase the level of industry life science research conducted in the state. One way to do this is by encouraging and facilitating university/industry research partnerships.

Tactics

This section outlines the key tactics that will help position Missouri to accomplish this strategy and describes the suggested actions to be implemented in support of the strategy.

- Encourage the state’s research universities and other research organizations to strategically position themselves to invest and build by focusing their key research around core competency areas for which Missouri can become internationally recognized.
- Address the vital need for additional research facilities at the research universities that can house and support additional faculty, provide access to key specialized facilities, attract additional federal and other research support, and further build Missouri’s research stature in core areas.
- Undertake innovative collaborations that can attract plant and agriculture-related, human disease treatment, environmental technologies, and other industries to increase their R&D presence in Missouri.
- Build and expand the basic science and research base, and its applications, in ways that increase the potential linkages to firms; the commercialization of technology within the state; and building of scientific networks among academe, industry, and the nonprofit sectors.
- Attract star faculty to Missouri’s higher education and other research organizations by dedicating significant state funding, together with philanthropic support, to fund recruitment packages.

Actions for Strategy One

It is proposed that Missouri pursue a broad set of reinforcing actions to build its research capacities in the life sciences that address simultaneously the needs for recruiting and retaining leading researchers, supporting innovative research projects and investing in research facilities and core laboratory equipment. These actions will differ in the specific funding sources to be used and specific time frames for the actions.

- **Action One:** Release funding and eliminate matching requirements for legislatively approved capital projects of the University of Missouri System that build capacity in the life sciences and related fields.

- **Action Two:** Create a Missouri Life Science Opportunity Fund that would invest in higher education and nonprofit research facilities, faculty/endowed chairs, and life science equipment.
- **Action Three:** Establish an R&D Partnership Program to encourage collaborations between the state’s higher education and research institutions and industry.
- **Action Four:** Provide funding to universities and research institutions to form joint consortia with industry clusters to pursue joint ventures and major funding opportunities.
- **Action Five:** Work with Missouri’s and neighboring states’ Congressional Delegations to secure federal funds and projects that further build the state’s life science base in both its higher education and nonprofit research organizations and industry.

Action One: Release funding and eliminate matching requirements for legislatively approved capital projects of the University of Missouri System that build capacity in the life sciences and related fields.

Building the R&D capacity of Missouri’s research institutions will require these institutions to attract world-class researchers and faculty and have the state-of-the-art equipment and facilities needed to conduct research. Missouri’s failure to invest in its research infrastructure will limit the ability of its institutions to compete for research funding.

In FY 2001, the University of Missouri System requested approximately \$85 million for projects that would construct or renovate laboratory and research space. Of this amount, \$30 million was provided to the university for the construction of the Life Sciences Building on the UMC campus. The 231,000-square-foot Life Sciences Building will house scientists from the College of Agriculture, Food and Natural Resources, School of Medicine, College of Arts and Sciences, College of Veterinary Medicine, Engineering, and the College of Human Environmental Science.

The Governor and legislature approved funding for other projects that are important to building Missouri’s life science research base, but the funds have not been released. Approved projects for which funds have not been released include

- Construction of a new building to house the School of Pharmacy and Nursing at UMKC. While the legislature approved \$30.5 million in state funding for this project in FY 2001, only \$1.7 million has been released. The campus also must raise \$7.6 million in nonstate sources for the project.
- Renovation of the Benton Statler buildings at UMSL. These buildings house the chemistry, physics, biology, and psychology labs. The state appropriated \$1 million in FY 1997 and \$2.5 million in FY 2000. Five million dollars was funded in FY 2001, but was not released. The total cost of the building is estimated at \$25 million. Approximately \$22.6 million is requested in FY 2004, which includes other campus improvements.
- Renovation of the Mechanical Engineering Building at UMR for which \$6.25 million was approved FY 2001 but was not released. The total cost of the project is estimated to be \$22.5 million, \$11.7 million of which is requested in FY 2004 and \$4.6 million must be raised by the campus.

No capital projects were approved for funding in FY 2002 or FY 2003. The University System is requesting more than \$60 million for projects needed to support the University’s R&D

enterprise. At the University of Missouri alone, there is demand for more than \$160 million for capital projects in FY 2004.

It is recommended that steps be taken to release the funds that already have been approved as soon as possible. It is also strongly recommended that, for life science related projects only, the requirement that 20 percent of the costs of new construction projects come from nonstate sources be waived. This would demonstrate the state’s commitment to the life sciences even in a time of fiscal and budget crisis, enabling the “fast tracking” of life science projects in Missouri’s public higher education system.

Resources Required: This action would require release of millions of dollars for previously approved UM capital projects.

Time Frame: This is an immediate priority of the strategy.

Lead Organization: The Coordinating Board for Higher Education and the University of Missouri System should work with the Governor’s Office and the legislature to facilitate release of the funds.

Action Two: Create a Missouri Life Science Opportunity Fund that would invest in higher education and nonprofit research facilities, faculty/endowed chairs, and life science equipment.

Battelle’s experience with life science centers throughout the United States shows that at the present time the most critical ingredients to strengthening the research enterprise are adequate facilities and the ability to recruit and retain outstanding research talent. Currently, academic health and higher education institutions are finding that those places that have sufficient and modern research facilities are the ones that can attract bioscience talent, and that talent, in turn, attracts the federal and industry research dollars. This is a much different paradigm than that of the past, but one that many regions and states are embracing.

Kentucky’s “Bucks for Brains” program, created with an initial \$100 million appropriation from the legislature, is aimed at making the University of Kentucky a top 20 public research university and the University of Louisville a nationally recognized urban research university. Officially called the Research Trust Fund Endowment Program, the state funds, which require a one-to-one match from private donations, are used to create an endowment that can be used to fund new faculty positions, give salary supplements to current faculty members, award fellowship stipends or scholarships, or provide assistance to priority programs that have received national distinction. Kentucky’s universities have used the program to attract internationally known researchers who bring with them highly trained staffs and millions of research dollars.

In May 2002, Oregon voters overwhelmingly approved Measure 11 authorizing issuance of \$200 million in Oregon Opportunity bonds. Proceeds will finance a new Biomedical Research Building at Oregon Health and Science University⁶; endow recruitment packages for Eminent Scholars; acquire new facilities at OHSU’s West Campus; and create a Rural Health Research Institute and a statewide Health, Education and Research Network. The bond will be matched by an already launched \$300 million capital campaign by OHSU, which projects investing as much

⁶ Formerly the Oregon Health Sciences University, now merged with the Oregon Graduate Institute into a unique state-funded nonprofit that is formally outside the Oregon University System.

as \$700 million from all sources in research facilities at its Marquam Hill and North Macadam campuses in Portland.

Texas, California, New York, Wisconsin, Michigan, Florida, and Georgia have proposed or enacted major capital facility plans for their academic and higher education institutions performing life science research (Table 7).

Modern facilities and fully equipped labs with state-of-the-art instrumentation will be needed in Missouri to attract the talent and research support necessary to become a first-tier state in the life sciences. So, in addition to meeting the current demand for capital investments, Missouri must make additional significant investments to attract faculty and researchers and to assist the state’s research institutions in constructing state-of-the-art facilities.

Georgia Research Alliance Investments Lead to Increased Life Science R&D

Beginning in 1990, a consortium of Georgia’s business leaders conceived and founded the Georgia Research Alliance (GRA) to “foster economic development within the State of Georgia by developing and leveraging the capabilities of the state’s public and private research universities in order to assist and develop scientific and technology-based industry, commerce, and business in Georgia.”

GRA’s investments in core facilities and endowed chairs for recruiting star faculty have helped Georgia greatly expand its life science R&D. Between FY 1997 and FY 2000, total Georgia NIH awards increased by 47.5 percent, compared with a 31 percent increase nationally.

Since 1992, the State of Georgia has invested more than \$300 million in GRA projects. As of FY 2000, GRA had established endowments for 37 Eminent Scholar positions, 13 of which are in the biosciences. In FY 2001, GRA funded seven new Eminent Scholar positions, five of which are in the areas of functional genomics and bioinformatics.

GRA also enhances research productivity by investing in the physical infrastructure necessary for effective research and development. More than 40 research facilities and centers of research excellence have had their construction, renovation, modernization, expansion, or equipment needs supported by GRA investments; many of these are in the life sciences.

Missouri’s fiscal situation, coupled with the Hancock Amendment, which restricts the rate of growth in total state revenues to the rate of growth in personal income without voter approval, has made it difficult to meet the capital investments required by the state’s universities and research institutions. Yet, these investments may very well determine whether the state will succeed in becoming a leader in the life sciences.

To provide the funding needed to build Missouri’s life science R&D capacity, it is recommended that the state create a Missouri Life Science Opportunity Fund. The fund could be tapped by the state’s public and private research institutions to construct facilities, recruit scientists and researchers, create endowed chairs, and purchase specialized equipment in the life sciences.

Criteria to be used in allocating these funds include, but are not limited to, the following:

- Consistency with identified core competency areas
- Evidence of potential or actual industry and federal or other funds matched/leveraged
- Potential for commercial and economic impact.

Table 7: Recent State Bioscience and Technology Investments

State	Bioscience Initiatives	Investment	Time Frame
California	California Institute for Bioengineering, Biotechnology, and Quantitative Biomedical Research	\$100 million to be matched by \$200 million in private funds	FY 2002–2004
Florida	Florida Technology Development Initiative—targeted to two sectors, one of which is biotechnology	\$100 million	Proposed by the Governor, currently under consideration by the legislature
Georgia	Georgia Research Alliance	\$300 million \$30 million	FY 1992–2002 FY 2003
Illinois	Capital project funding for bioscience facilities at universities and medical centers	\$370 million	FY 2001–2005
Indiana	21st Century Fund (includes life sciences but is not limited to life sciences)	\$30 million	FY 2003–2004
Kentucky	Research Challenge Trust Fund (includes but is not limited to life sciences)	\$110 million— matched by equal amounts raised by universities	FY 1997–present
Louisiana	Proposed spending on technology infrastructure, scientific equipment, and recruitment of Eminent Scholars with a strong focus on the life sciences	\$200 million	Proposed in 2002, \$150 million proposed as a bond issue to be amortized starting in FY 2003–2004
Michigan	Life Sciences Corridor	\$50 million per year for 20 years	FY 2000–FY 2025
New York	Awards for life science capital facilities	\$52.8 million	FY 2002
	Proposed Centers of Excellence, including a Bioinformatics Center	\$250 million	Proposed in FY 2003
Ohio	Third Frontier Project aimed at stimulating technology research in fields including the life sciences	\$1.6 billion over 10 years	Proposed in 2002
Pennsylvania	Life Science Greenhouses	\$100 million in one-time funds for three regional Life Science Greenhouses	FY 2002
	Life Science Venture Capital	\$60 million in one-time funds for three regional venture funds	FY 2002
Texas	Capital for construction of facilities, lab expansion, and equipment acquisition, including life science facilities	\$385 million	FY 2002
Wisconsin	BioStar, an initiative to build state-of-the-art life science research centers on the University of Wisconsin-Madison campus	\$317 million \$24 million \$27 million	FY 2000–2010 FY 2000–2001 FY 2002–2003

Support for the fund could come from multiple sources including the state’s tobacco settlement funds, revenue from cigarette taxes, or higher education bonds. It is recognized that the life science base in Missouri has suffered significant setbacks in potential funding streams recently with the reappropriation of tobacco settlement funds and the failure of the Health Life Science ballot initiative. Seeking alternative funding streams is critical.

States Dedicating Tobacco Settlement Funds to Bioscience-Related R&D

- Colorado
- Connecticut
- Illinois
- Kansas
- Louisiana
- Maryland
- Massachusetts
- Michigan
- Minnesota
- Missouri
- New Jersey
- New Mexico
- Ohio
- Oregon
- Pennsylvania
- Utah

In 2001, the National Conference of State Legislatures reported that 16 states had passed budgets and/or enabling legislation to use some portion of their tobacco settlements for bioscience-related efforts. Michigan, the first state to dedicate tobacco settlement funds for bioscience research, has allocated \$50 million a year over a 20-year period for an effort called the Michigan Life Sciences Corridor. Of this \$50 million, 40 percent will be used to fund basic research at four Michigan research institutions, 50 percent will be used to fund collaborative university/industry research projects aimed at developing commercial products and processes, and 10 percent will be used for commercialization activities aimed at bringing products to market. See Appendix B for a description of state bioscience initiatives.

Missouri had originally planned to dedicate a portion of its tobacco settlement funds for life science research and development. In 2001, Governor Holden established, by Executive Order, the Missouri Life Sciences Research Account (MLSRA) to be “used strategically to enhance...the State of Missouri’s capacity to serve the health and welfare of the residents of Missouri as a center of life sciences R&D.”⁷ In 2002, an RFP was released, and 17 letters of intent and 15 full proposals were

submitted. Table 8 lists the proposal topics and teams, and Figure 20 shows the locations of these teams. Although these awards were never made due to the reallocation of the funds, it is important to understand the synergy that was generated across the state. This points to the real potential for research collaboration in the future.

Approximately \$82.5 million will be needed annually for the next 10 years if Missouri is to be competitive in developing its life science base. It is proposed that this amount be invested in the Life Science Opportunity Fund. Resources for the fund would come from several sources including future tobacco settlement revenues, cigarette tax revenues, the state’s General Fund, and a higher education bond issue.

A potential source of funding that had been under consideration was the Health Life Science ballot proposal, which was initiated by Citizens for a Healthy Missouri. It was estimated that this proposal, which would increase the tax on cigarettes, would generate more than \$40 million annually. However, the ballot initiative failed in the November elections.

⁷ www.lifesciences.state.mo.us.

Table 8: Proposals Submitted for MLSRA Funding, 2002

Proposal Topic	Submitting Team
Missouri Structural Biology Magnetic Imaging Resource— Would provide a shared central facility that would provide researchers with access to ultra-high-field nuclear magnetic resonance imaging instrumentation.	Washington University (WU), Danforth Plant Science Center (DPSC), University of Missouri-Columbia (UMC), Saint Louis University (SLU), and University of Missouri-Kansas City (UMKC)
Missouri Environmental Sciences Coalition— Proposal aimed at increasing capacity and infrastructure critical to combating threats to the Missouri ecosystem. Initiative would build on the strengths of the submitting institutions and Fort Leonard Wood.	University of Missouri System (UMS), University of Missouri-Rolla (UMR), SLU, UMC, Southeast Missouri State University (SEMO), and Southwest Missouri State University (SMSU)
Missouri Biomaterials Consortium— Would provide foundation for development of advanced biomaterials for biomedical applications.	UMR, UMKC, UMC, University of Missouri-St. Louis (UMSL)
Life Sciences Research for Missouri’s Agriculture: Food, Fiber, and Biofuels— Targets proteomics, agriculture, and plant and animal sciences to strengthen Missouri’s capacity to take life science discoveries from lab to marketplace.	UMC, DPSC, UMR, SEMO, SMSU, The Jefferson Agricultural Institute (JAI), Truman State University (TSU)
Western Missouri Program in Structural Biology— Program will investigate structure and changes in structure that occur in biomolecules and biomolecular assemblies.	UMC, Kansas City Area Life Sciences Institute (KCALSI)
Preventive Care Research Center— Will build on existing endowed chairs.	Truman Medical Center—Kansas City (TMC), UMKC
Structural Biology and Drug Design— Would support purchase of major instrumentation that will constitute a core facility for structural biology, proteomics, and drug design in St. Louis region.	UMSL, SLU, WU
Nano-microscopy Life and Aerosol Science Consortium— Would expand scope of a regional atomic resolution microscopy facility at UMSL.	UMSL, WU, UMC
Functional Genomics and Investigative Animal Center— Will provide opportunities to train investigators to use transgenic animals to answer important biomedical questions.	UMKC, Children’s Mercy Hospital—Kansas City (CMH), St. Luke’s Hospital—Kansas City (SLH), TMC
Health Aging Life Science Research Center— Will expand research capacity of partner schools by expanding research staffs, purchasing equipment, renovating research space, and securing leading geriatric consultants.	Kirksville College of Osteopathic Medicine (KCOM), TSU, UMC, UMR, SLU

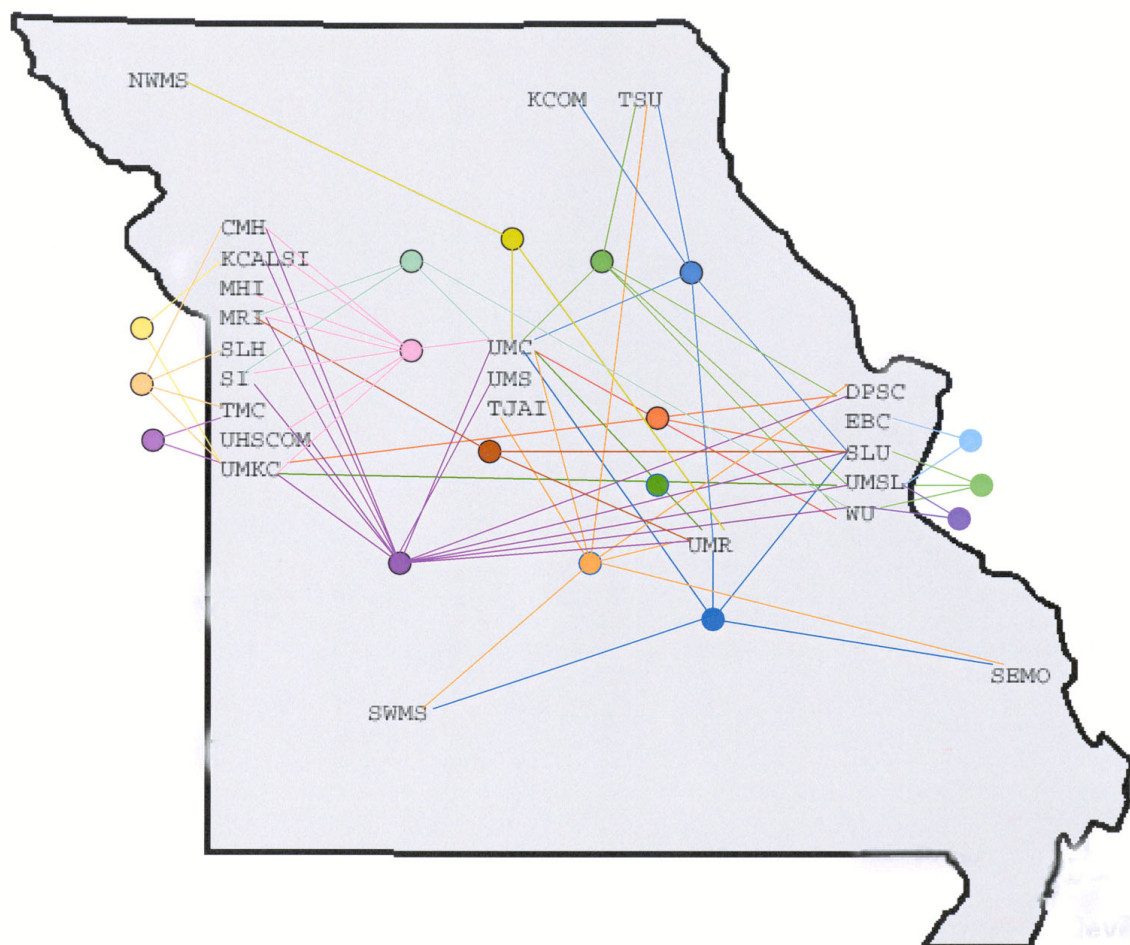
Table 8: Proposals Submitted for MLSRA Funding, 2002 (continued)

Proposal Topic	Submitting Team
Enhancing Computational and Structural Biology in Missouri —Would increase capabilities in protein biology and proteomics at the DPSC with goal of providing cutting-edge tools of proteomics and computational and structural biology. Instrumentation would be made available to collaborators.	DPSC, TSU, UMC, UMSL, WU
Missouri Bioinformatics Research Network (MBRN) —Would build a computational research infrastructure to enhance collaboration among participating institutions.	UMS, CMH, DPSC, Midwest Research Institute (MRI), SLU, Stowers Institute for Medical Research (SI), University of Health Sciences College of Osteopathic Medicine (UHSCOM), UMC, UMKC, UMR, UMSL, WU
Enabling Technology for Proteomics Research —Goal is significant proteomics-enabling technology enhancements at Missouri-based KCALSI participating institutions. Enhancements include equipment acquisitions and staffing support.	KCALSI, UMKC, SI, MRI, UMC, CMH, UHCOM, MidAmerica Heart Institute (MAHI)
Missouri Institute—Bioterrorism and Infectious Diseases —Will develop novel statewide organization to combat and study infectious diseases and bioterrorism.	SLU, MRI, UMR
Build Research Capacity in Cancer Therapy —Involves a system-level commitment to expand UMC's existing high-quality cancer treatment and educational facility, the Ellis Fischel Cancer Center, into an integrated multidisciplinary NCI-designated cancer research center.	UMC, MRI, SI, WU

The legislature could make a direct appropriation to the fund, but this will be difficult given the state's current fiscal situation. An alternative to providing a direct appropriation would be to issue bonds. Faced with a severe shortage of cash, the Virginia General Assembly has just approved a \$1.6 billion bond issue to finance construction and renovation projects on the state's college campuses. The bond issue has not yet been approved by the Governor and will require voter approval. In November 2000, North Carolina voters overwhelmingly supported a \$3.1 billion Higher Education Improvement Bond to fund new construction and renovation projects at North Carolina's colleges and universities. A bond issue, with the resources devoted to higher education, could be initiated with the proceeds dedicated to the Life Science Opportunity Fund. The bonds would initially be paid by the state, with the universities assuming payment after a five-year period.

Resources Required: It is proposed that \$825 million, to be provided over 10 years, will be required to increase the research capacity and world-class stature of Missouri's research institutions and to produce economic benefits for the state. These funds would be generated from multiple sources including dedicated tobacco settlement monies, revenue from an increase

Figure 20: Missouri Institutions Collaborative Efforts Proposed for MLSRA Funding



in cigarette taxes, and a bond issue for higher education. It is recognized that the life science research base has experienced significant setbacks in potential funding streams recently with the reappropriation of the tobacco settlement funds and the failure of the Health Life Science ballot initiative.

Time Frame: This is an immediate priority of the strategy. Due to the recent funding stream setbacks, it is critical to the success of this strategy that alternative funding sources be identified immediately to ensure that world-class research is developed and supported in Missouri.

Lead Organization: It is proposed that MTC administer the Missouri Life Science Opportunity Fund. In the event that MTC cannot award funds to private research institutions, a third-party intermediary organization, such as the Innovation Centers, could be used to distribute the funds.

Action Three: Establish an R&D Partnership Program to encourage collaborations between the state’s higher education and research institutions and industry.

If Missouri is to become a leading life science center, it needs to build sustained relationships between its life science companies and the state’s research institutions. One way to accomplish this is to provide funding for collaborative university/industry applied research projects. Such projects help build relationships between researchers and companies and provide support for activities that help to move technology to the point where private investment capital can be obtained.

At least a dozen states have matching grant programs that provide an incentive for firms to support research projects at local research institutions. National best practices suggest that matching grant programs are the most effective method when compared with other types of university/industry partnerships that exist to promote technology commercialization. Another approach to providing funding for higher education/industry partnerships is to use tax credits to build stronger and more sustained relationships between state industries and research institutions.

It is recommended that Missouri create a Research and Development Partnership Program that would provide matching grants for industry research projects conducted by Missouri research institutions. The industry partner must match the state funds on a 3:1 basis.

Resources Required: It is proposed that \$3 million be provided on an annual basis to support this initiative. This funding would be matched by \$9 million in industry support.

Time Frame: This is a mid-term priority of the strategy.

Lead Organization: Funding should be provided to MTC to implement the R&D Partnership Program. In the event that MTC cannot award funds to private research institutions, a third party intermediary such as the Innovation Centers should be used to award grants.

BioSTAR

An excellent example of an industry/university matching grant program in the biosciences is the University of California’s Biotechnology Strategic Alliances in Research (BioSTAR) program. Established in 1996, this mechanism links life science companies with researchers in their field through a modest matching grant. BioSTAR involves a highly competitive process in which research proposals are peer reviewed and companies must provide at least half the cost of the project. Since its inception, BioSTAR has fostered linkages between many of California’s small, emerging, life science companies and the University of California campuses, providing a highly valuable competitive edge to its emerging, small, life science companies.

Action Four: Provide funding to universities and research institutions to form joint consortia with industry clusters to pursue joint ventures and major funding opportunities.

Missouri has a large number of research institutions with expertise in various aspects of the life sciences and other related disciplines in engineering, information technology, and chemistry. At the same time, the most challenging, high-priority, and high commercial-payoff efforts are found in areas calling for multidisciplinary research.

Key challenges for Missouri include leveraging the research being conducted in the state’s various research institutions, connecting researchers and the industrial community, and encouraging collaboration and connectivity among these institutions that can help increase the state’s ability to increase the level of federal and industry R&D funding captured by Missouri and to move research towards commercialization. The Kansas City Area Life Sciences Institute was created to encourage such collaboration in the greater Kansas City region.

As discussed previously, if Washington University is excluded from the calculations, Missouri moves from 12th to 29th in NIH awards. Steps must be taken to encourage the state’s institutions to develop proposals and projects that increase the state’s market share of total NIH awards. One way to do this is by providing planning funds to help design and form consortia and joint ventures among the state’s research organizations that can compete more effectively for federal R&D funding, particularly major centers and institutes.

To encourage and facilitate the development of collaborative research relationships that include multiple research institutions from all regions of the state and companies, it is proposed that small planning grants be made available to support the development of consortia and other joint ventures. Awards of \$50,000 to \$100,000 would be provided to organize consortia and offset the costs of developing proposals and joint ventures. Consortia could be organized to compete for federal discretionary funds, a key factor identified in the benchmarking analysis as an important component in best practice regions.

Resources Required: It is proposed that this initiative be funded at \$300,000 annually.

Time Frame: This is a mid-term priority of the strategy.

Lead Organization: Funding should be provided to MTC to administer this program, working with the state’s higher education institutions and philanthropic and private sectors to seek and secure federal centers, institutes, and related funding opportunities.

Action Five: Work with Missouri’s and neighboring states’ Congressional delegations to secure federal funds and projects that further build the state’s life science base in both its higher education and nonprofit research organizations and industry.

Historically, federal R&D support has played a very important, if often unheralded, role in building up the core competencies of leading technology regions. The importance of discretionary R&D support in building Silicon Valley and the Route 128 corridor in Massachusetts has been well documented. The recent rise of northern Virginia as a leading Internet region and the rise of Maryland as a center for the life sciences also reflect years of strong federal discretionary R&D support, in Maryland’s case through the National Institutes of Health.

Missouri needs to identify key areas where the state, working in partnership with its neighboring states of Kansas and Illinois, can compete successfully for federal discretionary funding. Missouri should work closely with its own Congressional delegation and those of its neighboring

states to ensure that Missouri and its highly rated research institutions are given strong consideration and viewed as a key region for life science research funding.

Resources Required: No new resources will be required for this action.

Time Frame: This is a mid-term priority.

Lead Organization: The Missouri Congressional delegation, working with the Kansas and Illinois delegations.

STRATEGY TWO: CREATE A CRITICAL MASS OF LIFE SCIENCE COMPANIES BY FOCUSING ON COMMERCIALIZATION AND ACCESS TO CAPITAL FOR NEW FIRM CREATION, EXPANSION, AND RECRUITMENT.

Economic payoffs from investing in the life sciences can be significant. Across high-technology industries, studies have shown that academic research contributed most to the drug and medical product industry. One study found that 31 percent of new products and 11 percent of new processes in the biomedical field could not have been developed, without substantial delay, in the absence of academic research.⁸

But research by itself does not generate economic development results. Strong links must be established between universities and industry to advance life science industry development. The key issues regarding technology commercialization involve bridging the gap between innovations and discoveries made in research laboratories—whether university-based, nonprofit-based, or private industry-based—and commercial development of those research discoveries undertaken by life science businesses. The three key dimensions of technology commercialization are

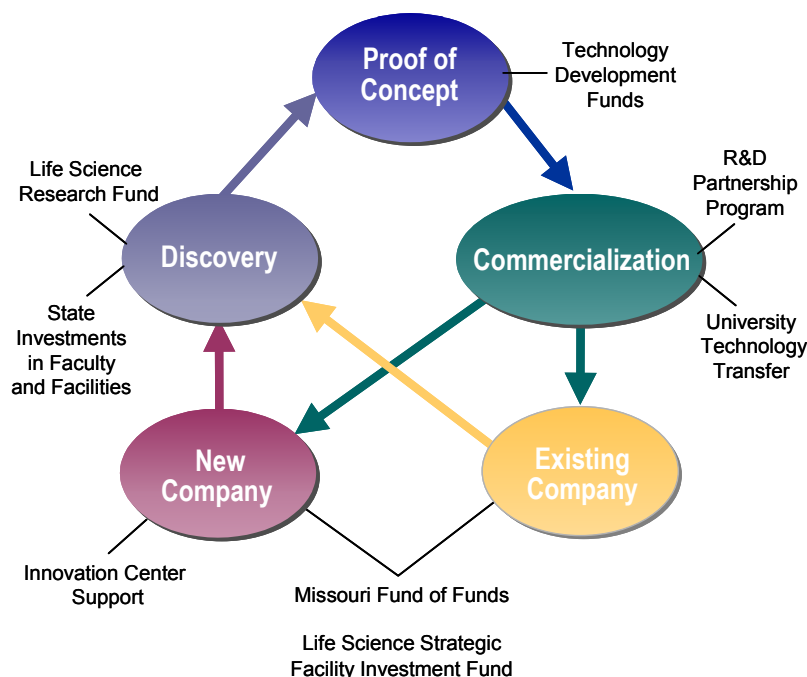
- Technology transfer efforts within a university, which involve setting the right incentives, culture, and processes. Success also depends on the availability of qualified staff, particularly those who bring business expertise to help identify and negotiate with appropriate commercial entities and funding to pay for legal expenses involved in filing patents.
- The ability to further the commercial development of a research discovery, involving the assessment of the commercial value of the research discovery and setting out a commercialization plan, including proof-of-concept applied research.
- Support for the formation and growth of new start-up ventures, including access to seed-stage capital and access to management talent and value-added management assistance for business planning, marketing, and attracting capital. Incubators in particular play an important role for life science companies because of the need for wet-lab and other specialized facilities, as well as their ability to offer one-stop assistance and networking for life science companies.

Missouri’s life science industry base, while significant and expanding in terms of the number of establishments in several key areas, overall shows signs of maturity because of the historic state base in bioprocess manufacturing. One reason for this is that growth in Missouri’s life science industries has been driven by growth in the hospital and laboratory sector. Missouri has not kept pace with the nation in terms of the growth of its research and testing and drug and pharmaceutical sectors, the industries that are the most innovative and hold great promise for future

⁸ Edwin Mansfield, “Academic Research and Industrial Innovation,” *Research Policy*, 1998, 26: 773-776.

growth. To become a leading center for the life sciences will require that Missouri create a stronger innovation climate in which university research is advanced toward commercialization, there are proactive technology transfer interfaces, and new companies are created and emerging companies succeed and grow (Figure 21).

Figure 21: Overview of Missouri’s Life Science Strategy



Tactics

Key tactics that will help position the region to accomplish this strategy include

- Providing incentives and mechanisms to link research to technology solutions and applications and subsequent commercialization.
- Building partnerships with industry by encouraging sponsored research; providing access to facilities and equipment, shared facilities with pilot plants, and prototype facilities.
- Focusing attention on addressing the unique and special needs of the state’s start-ups and their relationships with the research universities. These relationships are important, and quite different in nature than those that universities establish with larger firms. Start-up companies’ needs range from accessing equipment and facilities to requiring support for joint R&D projects.
- Offering in-depth assistance to entrepreneurs and start-up companies. Such efforts will require a commitment of resources and the involvement of experienced staff.
- Addressing the need for start-up wet-lab space by developing incubators and accelerators in emerging concentration areas of the state.

Actions for Strategy Two

- **Action One:** Revise and expand the mission of the Innovation Centers to provide in-depth assistance to technology entrepreneurs and make their services available statewide by establishing satellite operations in the second-tier metropolitan areas to enable these areas and rural parts of Missouri to obtain assistance.
- **Action Two:** Establish new and expand existing life science wet-lab incubators and accelerators throughout the state in areas with potential to develop firms in niche markets, including field test centers.
- **Action Three:** Create and invest (through appropriations or tax credits) in Technology Development Funds that would operate through appropriate third-party mechanisms in each major region of the state to undertake prototype development and other efforts to commercialize technology.
- **Action Four:** Review university policies and practices (distribution of royalties, disclosures, etc.) and revise as necessary to encourage and provide incentives to faculty to commercialize their technology through spin-offs or licensing to industry, particularly in Missouri. Secure additional staffing and expand functions (market assessments, equity participation, accessing capital) in the state’s public and private universities’ technology transfer, commercialization, and industrial liaison functions.

Action One: Revise and expand the mission of the Innovation Centers to provide in-depth assistance to technology entrepreneurs and make their services available statewide by establishing satellite operations in the second-tier metropolitan areas to enable these areas and rural parts of Missouri to obtain assistance.

The Missouri Department of Economic Development provides support on a 1:1 matching basis to four Innovation Centers located in Columbia, Kansas City, Rolla/Springfield, and St. Louis. These Innovation Centers provide management and technical assistance to entrepreneurs and emerging companies and provide space for start-up companies. Each of the centers differs somewhat in the level and range of assistance services provided; however, all are limited by the resources available to them.

It is recommended that the scope of services provided by the Innovation Centers be expanded to provide comprehensive, in-depth business development and commercialization support to

Oklahoma Technology Commercialization Center (OTCC)

OTCC plays an important, and generally neglected, role in Oklahoma by positioning Oklahoma entrepreneurs to grow viable businesses. One key way is by helping start-ups focus their business plans and strategies, through hands-on educational and training support and detailed consulting. OTCC also helps entrepreneurs secure angel financing and other early-stage funding (including a state seed fund program that it operates). OTCC has helped organize 44 angel investor groups across Oklahoma, involving 300 investors with a net worth of \$2 billion. Moreover, OTCC has established a certified Service Provider Program, which identifies proven, quality service providers representing intellectual property law, corporate law, business consultants, marketing, engineering, science, and financial consulting, who are interested in providing assistance and support to technology entrepreneurs. The most important contribution of OTCC is its activities in helping to stimulate investment deal flow as well as improving the quality of deal flow to private investors. In its first two years of operation, OTCC has served 467 clients, of which 268 have received detailed project assistance and 74 have been presented before angel investor and other financing sources with nearly \$15 million in hard-to-find pre-seed and seed capital dollars raised, leveraging more than four times the amount of state investment in OTCC operations.

entrepreneurs and start-up companies, placing particular emphasis on working with life science companies. The Innovation Centers should serve as a point of entry for start-up life science companies that can assess their needs, guide them through the commercialization process, and link them to a comprehensive network of commercialization assistance services. Services, many of which are provided by the centers currently, should include conducting technology and market assessments and providing specialized SBIR assistance, business mentoring, and matchmaking support.

To assist entrepreneurs in all regions of Missouri, it is recommended that some of the Innovation Centers establish satellite centers that would provide a point of entry for entrepreneurs and start-up companies but that would draw on the expertise of its sponsoring Innovation Center to provide specialized services. Areas such as Joplin, St. Joseph, and Cape Girardeau, for example, have a base for building enterprises in the life sciences, but these areas do not have a sufficient critical mass of entrepreneurs to warrant a full-fledged Innovation Center. The state should expand its funding to existing Innovation Centers to enable them to more adequately meet their original intent, and to increase their capabilities in the life sciences. The state also should help to form and provide services to satellite centers to serve a larger region.

Resources Required: It is proposed that funding for the four Innovation Centers increase from its current level of \$250,000 each to \$1 million each—for a total state investment of \$4 million annually—over the next four years. In addition, other actions would increase funds to the Innovation Centers for incubator and accelerator expansion and development and for helping to develop research parks.

Time Frame: This is an immediate priority of the strategy.

Lead Organization: The four Innovation Centers, working in partnership with MTC, should (1) establish minimum performance standards and expectations for each Innovation Center and (2) seek and secure increased funding to support meeting these standards. Some of the Innovation Centers should form satellite centers in up to three areas of the state over the next five years.

Action Two: Establish new and expand existing life science wet-lab incubators and accelerators throughout the state in areas with potential to develop firms in niche markets, including field test centers.

One way to capture the commercial value of discoveries coming from Missouri’s research institutions and to support the development of new life science companies is to create mechanisms and vehicles that enable individuals to start firms easily and to provide these firms with business mentoring, professional assistance, and logistical support services that will enable them to survive and grow. In addition to needing these services, start-up life science companies need access to specialized lab space.

To meet the need for specialized lab space and to provide support for start-up and emerging life science companies, it is proposed that Missouri create a network of life science incubators and accelerators, each of which would have available wet-lab space. Incubators provide small amounts of shared space, in the range of 500 to 1,500 square feet, with flexible lease terms and shared support services. Accelerators provide multitenant buildings that provide “post incubator space” for incubator graduates or for those firms not needing incubation. Accelerators offer an

environment in which firms can grow or expand, providing both office and wet-laboratory space and other support functions, such as conference rooms,

St. Louis has incubators that provide space for start-up life science companies. The Center for Emerging Technologies in St. Louis, one of the four state-supported Innovation Centers, has 92,000 square feet of space and contains wet and dry and DNA labs, among other biotechnology-related necessities. The Nidus Center for Scientific Enterprise is a 40,000 square-foot plant and life sciences incubator located in St. Louis. There are no life science incubators in Kansas City currently; however, planning is underway for the Kansas City Center for Technology that will include wet-lab space.

It is proposed that Missouri provide funding for the expansion of existing incubators and the development of new life science incubator and accelerator facilities. Funding should be made available to create or expand incubators that would operate in conjunction with the four Innovation Centers. If the state provides 50 percent of the cost of construction, it is estimated that \$14 million will be required for incubator/accelerator support over the next five years. Funding for the incubator/accelerator development programs should be given to MTC for distribution.

An alternative to directly appropriating the funds to MTC would be to create a special pool of funds that could be tapped by the Innovation Centers to build or expand life science incubator and accelerator space. Currently, the Missouri Department of Economic Development provides direct grants to four Innovation Centers. In addition to the increase in operation support for the Innovation Centers discussed previously, a “Special Projects” pool could be created that could be tapped to support specific facility enhancements needed for incubators and accelerators around the state.

Resources Required: It is proposed that \$14 million in state funding be made available over a five-year period.

Time Frame: This is a short-term priority of the strategy.

Lead Organization: MTC should be given responsibility for selecting incubator/accelerator projects to receive funding.

Action Three: Create and invest (through appropriations or tax credits) in Technology Development Funds that would operate through appropriate third-party mechanisms in each major region of the state to undertake prototype development and other efforts to commercialize technology.

It is proposed that three regionally based Technology Development Funds (TDF) be created. Missouri has a strong and growing base in basic research, and its research institutions are making important strides to upgrade their technology transfer and commercialization activities. Nevertheless, a definite gap was identified in the tools available to encourage technology transfer and commercialization. Presently, there are no sources of funding for the follow-on activities needed to determine commercial potential, to identify potential licensees, or to determine whether there is a basis for forming a new firm around a technology.

The Technology Development Funds would identify intellectual property within both higher education and research institutions and industry and provide funding in the range of \$25,000 to \$100,000 to undertake due diligence, either by hiring a consultant or conducting a review in-house, to determine whether there is any commercial value. In some cases, the researcher may be provided small additional funds to further refine the “proof of concept” of the research.

This level of funding is needed to bridge the gap between basic science, which is most often funded by the federal government, and the development of technology with commercial potential. The funds would make awards to be used to increase the value of a technology and to develop it to the point at which its commercial potential has been demonstrated. Awards could be used to develop a prototype or conduct further research that helps determine market value. Given that this funding would be provided prior to determining commercial potential, the recipients of the awards would not be required to make any repayments to the TDF. If the TDF is used in connection with a local commercialization fund, a return on investment may be required by the local commercialization fund to sustain itself.

A number of universities, such as Purdue University and Boston University, have established or are considering establishing Commercialization Funds. Numerous medical schools and centers also have established a variety of such funds, including Mayo, Cleveland Clinic, Children’s Hospital Boston, and Baylor. The above text box describes the technology commercialization component of Boston University’s Community Technology Fund.

Missouri’s Technology Development Funds would not serve a single institution; rather, they would seek to commercialize intellectual property originating with entrepreneurs, and in companies as well as in universities and other research institutions.

Resources Required: It is recommended that three regional funds be created, with an initial capitalization of \$3 million each, for a total of \$9 million. In the case of a pre-existing regional commercialization fund, the funds may be allocated to such a fund to strengthen its capital base and sustain its operations.

Time Frame: This is an immediate priority of the strategy.

Lead Organization: MTC should be given responsibility for selecting the regional organizations that will administer the Technology Development Funds.

Boston University’s Community Technology Fund

The Community Technology Fund (CTF) is Boston University’s name for its combined licensing office, commercialization function, and direct-investment fund. A separate unit of CTF, called “New Ventures,” is responsible for developing new start-up companies based on BU technologies.

New Ventures makes “technology development awards” that are designed to “bridge the gap between government funded basic science and the more developed technologies that are of interest to commercial entities.” The grants, which range from \$20,000 to \$50,000 but can be up to \$100,000 under special circumstances, can be used to finance commercialization research or reduction to practice. Projects are selected based upon commercialization potential and the feasibility that the award will increase the value of a technology or the likelihood that it will be commercialized. The awards are not repayable.

Action Four: Review university policies and practices (distribution of royalties, disclosures, etc.) and revise as necessary to encourage and provide incentives to faculty to commercialize their technology through spin-offs or licensing to industry, particularly in Missouri. Secure additional staffing and expand functions (market assessments, equity participation, accessing capital) in the state’s public and private universities’ technology transfer, commercialization, and industrial liaison functions.

Traditionally, commercialization of R&D has not been a high priority among universities. However, during the last decade, one after another of the nation’s leading research universities have restructured and placed increased emphasis on connecting their R&D capabilities to the commercialization strengths and responsibilities of business. This “connectivity arena” remains more an art than a validated scientific approach; but, as the universities have gained more experience, knowledge, and results, it has become clear that R&D will not “magically” pass over the transom from university to business. Consequently, universities are putting strategies in place to facilitate the commercialization of university discoveries.

In 1999, the University of Missouri engaged Battelle to conduct an assessment of the university’s research and technology transfer policies. At that time, the Battelle team found “relatively weak support, in terms of both formal and informal rewards, for excellence in technology transfer.”⁹ In response to recommendations in the report, the university created a new Office of Technology and Special Projects to facilitate transfer of technology to the private sector for commercialization. The office serves the entire University of Missouri System.

While the creation of this office is an important first step, additional staffing and resources will be required as this strategy is implemented and total R&D funding increases. Presently, the office has a staff of four professionals; the Executive Director; one Marketing and Business Development Officer; and two Senior Licensing and Business Development Associates, one of whom focuses on the life sciences. Additional expertise will be needed to help faculty and researchers through the commercialization process, particularly if Missouri wants to capture the technology commercialization potential of its growing research base.

In addition, all of Missouri’s research institutions should develop and implement strategies that will encourage faculty and researchers to pursue commercialization and to provide them with the support needed to enter into commercial partnerships and/or create new companies. It is recommended that Missouri’s research institutions

- ***Implement policies that will provide incentives to researchers to participate in and support technology transfer activities.*** One of the greatest motivators for researchers to pursue technology transfer is additional resources to continue their research. Several universities, including the University of California System, Penn State, the University of North Carolina, the University of Virginia, and the University of Wisconsin-Madison, changed their patent distribution policies to provide an additional incentive for faculty to patent and license their inventions. In addition to changing the distribution of patent revenues, the University of California reviewed its academic review process to find ways to recognize and reward faculty for receiving patents and licenses.
- ***Establish industrial liaison offices*** to serve as a “one-stop shop” for businesses interested in sponsoring research and partnering with the university or research laboratory. Industrial

⁹ *Assessment of University of Missouri Research and Technology Plans and Strategies*, May 1999.

liaison offices aggressively market university research and technology and actively seek out companies with which to partner. In addition, such offices could work to increase faculty understanding of industry needs.

- ***Place greater emphasis on technology commercialization.*** Universities and other research institutions are experimenting with a variety of approaches to provide the types of services needed to position technology for the marketplace. They include implementing a systematic process for exploring opportunities for start-up companies; providing funds for additional R&D needed to improve commercialization potential (this type of funding will be available through the proposed Technology Development Funds described previously); and linking start-up companies with sources of pre-seed and seed capital. In addition, a few universities and research centers have developed separate corporations to commercialize technology developed at their institutions.

Resources Required: It is estimated that each research institution will need to invest \$250,000 to \$350,000 annually to expand its technology transfer and commercialization program.

Time Frame: This is a short-term priority of the strategy.

Lead Organization: Each research institution must take responsibility for expanding its technology transfer function and increasing its focus on commercialization.

STRATEGY THREE: CREATE A SUPPORTIVE BUSINESS, TAX, AND REGULATORY CLIMATE FOR LIFE SCIENCE COMPANIES, AND A NATIONAL AND INTERNATIONAL IMAGE AS A LEADING CENTER IN THE LIFE SCIENCES.

Key factors affecting the success of the bioscience industry include capital, technology, and talent. However, fundamental issues that also affect the growth of regional economies include technology infrastructure, tax policy, regulatory climate, economic incentives, quality of life, cost of doing business, real estate development, and general business leadership.

Two critical needs that must be addressed if Missouri is to attract, grow, and retain life science companies are the need for investment capital and the need for commercial life science facilities. Focus group meetings with industry across the state identified specialized lab space as a key life science development issue across Missouri. While the state has begun to address the need for seed capital, Missouri also must further develop and build an indigenous venture capital industry focused on the life sciences.

Missouri today has limited resources that can be used to assist emerging and growing life science companies or to attract companies to locate in the state. Unlike other states, Missouri does not have a portfolio of economic development incentive programs that might be attractive to life science companies. Missouri can, however, become more competitive by making changes in the state’s tax code to benefit start-up life science companies, support the development of research parks, and attract a larger share of federal R&D dollars.

Tactics

The following tactics should be pursued to create a climate in Missouri that will lead to the creation, growth, and retention of life science companies in the state.

- Encourage and facilitate the establishment of an indigenous venture capital market that includes life-science-focused venture capital funds. The public sector never will be able to meet the capital needs of life science companies nor should it. Government can, however, play a catalytic role by providing initial seed capital and incentives to encourage individuals and local institutional investors, including public pension funds, to invest in venture capital funds that commit to investing in local companies.
- Restructure tax codes to benefit emerging and growing life science companies. Using tax incentives to encourage corporate investment is a traditional economic development technique. Most tax incentives were designed initially to assist traditional manufacturers and to encourage job creation. Tax policies should be examined and revised to better reflect the situation of life science and other “New Economy” industries.
- Create incentives to encourage private real estate markets to build facilities to house life science companies and use existing economic development programs to assist established life science companies to develop facilities.
- Create an image of Missouri as a life science center. Creating an image of a state or region as a life science center is important in helping the region attract companies, researchers and skilled workers.

Actions for Strategy Three

- **Action One:** Create a large-scale (\$150 million to \$200 million), Missouri-based “fund of funds” to serve as a vehicle for institutional investment of all kinds in private equity funds that in turn invest in life science start-ups and in the real estate necessary to house them. Encourage Missouri’s public pension fund boards to allocate a small portion of their pension assets to this fund.
- **Action Two:** Pursue a comprehensive approach to address life science companies’ specialized facility requirements, including establishing a life science strategic facility investment fund that will provide financing for leasehold improvements and multitenant life science facilities, and providing state support for research park development.
- **Action Three:** Make changes in Missouri’s tax structure to provide incentives for the growth and development of the state’s bioscience base, including changes in the R&D and sales and use taxes as well as an overall comprehensive review and assessment of the state’s tax structure.
- **Action Four:** Establish a Life Science Special Project Fund through MTC for large-scale, nonuniversity projects to retain, attract, and expand firms in the state.
- **Action Five:** Develop a statewide image, marketing, and business development effort that builds on and supports current regional efforts to market Missouri as a center for the life sciences.
- **Action Six:** Initiate a statewide education campaign on the benefits and importance of the life sciences to the state’s economic future.

Action One: Create a large-scale (\$150 million to \$200 million), Missouri-based “fund of funds” to serve as a vehicle for institutional investment of all kinds in private equity funds that in turn invest in life science start-ups and in the real estate necessary to house them. Encourage Missouri’s public pension fund boards to invest a small portion of their pension assets to this fund.

Missouri’s financial markets are not sufficiently developed to encourage private sector investments in the life sciences, and significant gaps exist at all stages from commercialization to pre-seed, seed, and later-stage investment. Steps have been taken recently to improve access to seed capital. A St. Louis-based seed fund, Prolog Ventures, has been created, and the proposed Technology Development Funds will address the need for commercialization funding. St. Louis, in implementing its plant and life science strategy, has been able to form three new funds focused on life sciences, with \$258 million total capital raised to date. But, these funds are in desperate need of further venture capital sources for later-stage funding of life science companies that they invest in at earlier stages and for funding of facilities for them if they are to grow, expand, and remain in the state. And other areas of the state have not had the success of St. Louis in raising private venture capital.

A potential source of venture capital, and one increasingly tapped in other states, that could provide pools of equity capital for investment in life science companies and facilities in Missouri is the state’s public pension funds. Of all investors who may be interested in private equity, however, pension funds (both public and private) are among the most conservative and risk averse. Pension assets usually are held in trust for the beneficiaries of a plan, and investment decisions are made by professional managers under intensive scrutiny of trustees who are held to the very highest fiduciary standards of prudence under American law and custom. Despite this fact, public pension funds in many states, including Illinois, Iowa, Kansas, Maryland, Michigan, Minnesota, Ohio, and Pennsylvania, make private equity investments; and California and New York’s public pension funds invest significantly in venture capital.

Missouri’s large public pension funds have historically been among the most conservative in the country, with no allocation whatsoever to venture capital or other types of private equity. However, as the pension funds seek to increase the average return on their total portfolio, they are beginning to consider venture capital investments. Missouri’s largest public pension fund, the Public School and the Non-Teacher School Employee Retirement Systems of Missouri (PSRS/NTRS), recently announced a portfolio allocation of 3 percent to private markets including venture capital. Missouri’s public pension funds are likely to resist any requirements that they make geographically targeted investments in private equity, particularly in light of an unsuccessful effort to do so in the past. (In the late 1980s, an ill-advised experiment known as SB20 legislatively mandated a geographically targeted program of direct company investment.) Instead, it is proposed that Missouri focus on creating the conditions, without legislative mandate, in which a wide range of

Maryland Venture Capital Trust

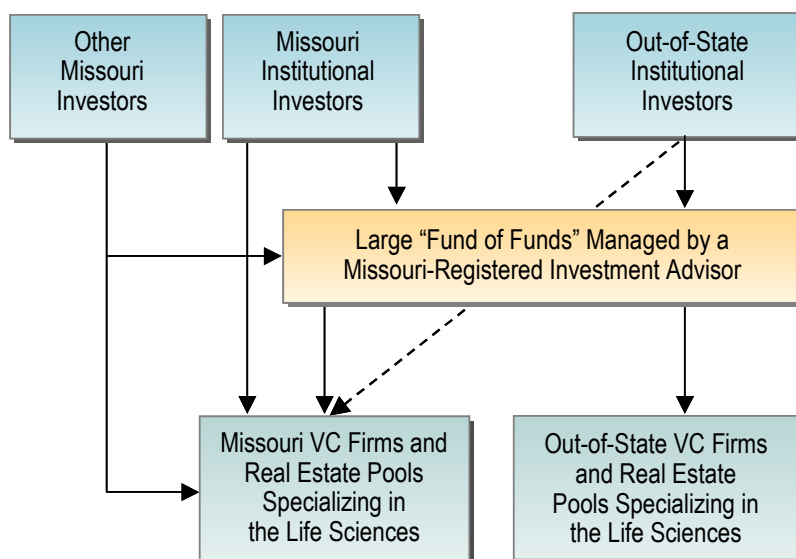
The Maryland Venture Capital Trust was created in 1990 to respond to a perceived need for seed and early-stage venture capital in the state. The program created a state-sponsored but privately managed venture trust that was designed to become a “fund of funds” investing state and public pension funds in a number of diverse venture capital partnerships, each managed by a different venture capital firm. The Maryland Venture Capital Trust selected eight private venture capital firms to manage the trust’s venture capital partnerships.

institutional investors will consider making jointly managed private equity investments in a way that also serves to place Missouri “on the map” for private equity (as is managed on the Coasts).

It is proposed that Missouri’s private institutional investors create a “fund of funds,” to leverage on the order of \$150 million to \$200 million dollars, that would serve as a vehicle for institutional investment of all kinds in private equity funds that, in turn, invest in plant- and life-science start-ups and in the real estate necessary to house them. Unlike Maryland’s Venture Capital Trust, which is a state-sponsored trust, Missouri’s fund of funds is proposed as an entirely private venture. It should not be “sold” to investors by potential asset managers, but rather called into being by leadership of the major institutional investors, including both private and public pension plans, and some of the same corporate and foundation investors already committed to Prolog and other venture funds.

Missouri’s fund of funds would seek to attract not only public pension investments but also investments from corporate and union pensions, banks, corporations, foundations, universities, and wealthy individuals from both within and outside of Missouri. The fund would invest in both local and out-of-state life science venture and real estate funds, although Missouri firms could be targeted for investment. It is anticipated that, once private and public pension funds are introduced to local venture and real estate partnerships through the fund, they may decide to make direct investment in these partnerships as well. Figure 22 shows how the “fund of funds” concept would work.

Figure 22: Missouri’s Fund of Funds



Note: The dashed line shows effects that come later, once the fund of funds is working and has established the creditability of Missouri-based VC partnerships and real estate pools serving this sector.

In addition, the State of Missouri is currently examining the feasibility of creating the Missouri Venture Capital Fund I. Oklahoma has initiated a similar model to promote the flow of financial capital in the state. In this model, the Oklahoma Capital Investment Board is equipped with tax credits that back a \$30 million fund of funds in which institutions are encouraged to invest. Should defaults occur that would cause investors to lose capital, the tax credits can be allocated to make the investors whole.

Resources Required: It is proposed that the state’s pension funds make a one-time investment of \$150 million to \$200 million in the Missouri life science “fund of funds.” In addition, the Missouri Venture Capital Fund I that the state and the Missouri Venture Capital Roundtable is examining is worthy of further consideration.

Time Frame: This is an immediate priority of the strategy.

Lead Organization: The leadership of Missouri’s major institutional investors should organize the fund of funds.

Action Two: Pursue a comprehensive approach to address life science companies’ specialized facility requirements, including establishing a life science strategic facility investment fund that will provide financing for leasehold improvements and multitenant life science facilities, and providing state support for research park development.

Key to ensuring that Missouri can attract and retain life science companies will be the ability to ensure an adequate supply of the specialized facilities that life science companies require. Life science companies need specialized wet-lab space with enhanced air-handling and sterility requirements. Typically, these facilities are not readily available in commercial or light manufacturing buildings and are very expensive to construct or add to existing facilities. A basic, no-frills, wet-lab tenant improvement can add up to \$100 per square foot or more in build-out costs, and more specialized wet-lab space for pilot production can be as much as hundreds of dollars per square foot.

However, emerging companies’ needs for access to multitenant facilities that include basic wet-lab improvements are not currently being met. Typically, these companies do not have the financial capital to construct their own facilities or even to finance their own tenant improvements, which can cost as much as \$2 million to \$5 million. A recent study documented an expected need within the next three years for 252,000 square feet of space among existing life science companies in the St. Louis region alone (not counting newly formed or recruited companies).

Missouri has limited tools for supporting the development of specialized facilities for life science companies, especially in addressing credit enhancement for tenant improvements and speculative multitenant facility development. Missouri’s most critical gap in life science facility development is in the area of assisting those emerging life science companies that are in the post-incubator phase and not of sufficient size to occupy their own facilities, typically requiring about 10,000 to 15,000 square feet. Approaches that have proven effective in supporting these emerging life science companies include support for leasehold improvements and more active speculative development of multitenant life science facilities, including at designated research parks.

It is proposed that Missouri create a Life Science Strategic Facility Investment Fund.

Missouri needs a long-term solution that can provide a targeted and flexible source of assistance for filling key financing gaps in life science facility development, similar to the successful effort pioneered in Connecticut with its BioScience Facilities Fund. It is proposed that a \$60 million Life Science Strategic Facility Investment Fund be created through the allocation of tax credits or a direct appropriation to a public-purpose private entity to be selected by the Missouri Technology Corporation.

The fund should be flexible in its approaches, considering whatever makes the most sense in a particular situation, such as creating a reserve fund, financing life science leasehold improvements, making direct investments in speculative facilities alongside private developers, and investing in research park development.

Connecticut BioScience Facilities Fund

The \$40 million in its Connecticut BioScience Facilities Fund is managed by Connecticut Innovations, Inc., on a deal-by-deal basis, structuring financing to meet the specific situation. The fund has provided direct-loan financing for tenant wet-lab improvements, structured a loan loss reserve fund to enable developers to acquire private financing, and provided innovative equity/direct-loan financing packages. Also, it is often an equity investor in the biotechnology firms that it lends to for tenant improvements. To date, the BioScience Facilities Fund has assisted in creating 200,000 square feet of laboratory space and closed on \$18.5 million in financing.

It also is proposed that Missouri provide support for life science research park development.

Along with these specific tools for financing wet-lab leasehold improvements and supporting speculative multitenant life science facility development, there is a need to advance the establishment of research parks near life science research drivers. Research parks across the United States have proven to be critical catalysts for strengthening a region’s technology industry base and generating growth far beyond the physical boundaries of the park itself. In the life sciences, in particular, the close link between basic research and commercial development calls for proximity in the location of emerging life science companies and research institutions. The success of life science oriented parks in Worcester, Massachusetts (adjacent to the University of Massachusetts Medical School), and Richmond, Virginia, demonstrate how even smaller regions can benefit from research parks. To advance the development of research parks, it is critical to identify sources for infrastructure improvements and land assembly and then to apply the specific facility financing tools for leasehold improvement and multitenant speculative development.

It is proposed that funding be provided for planning assistance, design, land assembly, and infrastructure improvements for research parks, as well as direct support for multitenant facility development. These activities could be undertaken directly by MTC or a third-party entity created for the purpose of developing research parks. Local redevelopment authorities and Innovation Centers could also play a role in planning and developing the parks.

Resources Required: It is proposed that \$60 million be raised for life science facilities, \$40 million of which would be targeted for the development of research parks, including the development of speculative buildings, and \$20 million of which would be used for leasehold improvements and facility development. This could be financed either as a tax credit or a direct appropriation. The state also should further explore the feasibility of designating tobacco settlement securitized funds to establish a life science facilities fund.

Time Frame: The creation of the Life Science Strategic Facility Investment Fund and establishing research park funding is a mid-term priority of the strategy.

Lead Organization: The MTC should take the lead on organizing the Life Science Strategic Facility Investment Fund and providing support for life science research park development.

Action Three: Make changes in Missouri’s tax structure to provide incentives for the growth and development of the state’s bioscience base, including changes in the R&D and sales and use taxes as well as an overall comprehensive review and assessment of the state’s tax structure.

Tax policies signal how states and localities prioritize their economic development efforts. Many states seeking to advance their life science industries are using their tax structures strategically to encourage private investment in life science firms, to ease the tax burdens on such firms, and/or to even the playing field of biotechnology firms with traditional industries.

Traditional tax incentives put in place to encourage the establishment and growth of companies—tax credits for job creation and investment—generally do not benefit young bioscience companies due to the lengthy development process required to bring new bioscience products to the market. In their early years, bioscience companies generally do not have profits and therefore tax liabilities that can be offset by tax credits.

At the same time, these young life science companies often are subjected to taxes, including sales and personal property, even when they are unprofitable and engaging in R&D efforts that can generate future economic growth. Rather than penalizing such firms by taking away scarce capital, many states are providing incentives to invest this scarce capital in the firm’s research and development to generate products and firm growth.

States are addressing the needs of bioscience companies by

- Providing a tax credit against corporate income taxes for research and development expenses.
- Expanding equipment tax credit programs to allow credits for equipment leased for at least two years.
- Exempting the applicable sales and use taxes paid on purchases of R&D activities.
- Allowing net operating losses (NOLs) of life science companies to be carried forward for as many as 15 to 20 years.
- Allowing tax credit transferability. New Jersey, for example, allows biotechnology companies with unused R&D tax credits to surrender those benefits to another corporation; Hawaii allows high-technology businesses to sell its unused NOL to another taxpayer; and Connecticut businesses with less than \$70 million in gross sales can exchange unused R&D tax credits with the state for a cash payment equal to 65 percent of the value of the credit.
- Providing specific tax credits for biotechnology companies. Arkansas provides income tax credits to biotechnology companies. The credits include a 30 percent tax credit on the cost of cooperative research with state universities; a 5 percent credit of the cost of construction, expansion, improvement, renovation, or purchase of a biotechnology facility; a 30 percent credit of the cost for training employees in biotechnology; and a 20 percent credit of the amount that the cost of qualified research exceeds the cost of such research in the base year.

Missouri does little to support the R&D efforts of emerging life science companies. Of the state’s many tax credit programs, few are applicable to emerging life sciences companies. For instance, the state’s R&D tax credit is an effective vehicle for more established companies, even providing for transferability to assist companies that are not yet profitable. However, the R&D tax credit is

limited in its availability to young life science companies because its benefit requires having prior research expenses. Moreover, the capital tax credit program, which provides a transferable tax credit to an investor in a qualified small business, including life science companies, has been exhausted for several years.

On the other hand, the tax credit programs have been the primary way that the state has assisted, either directly or indirectly, its efforts in technology-based economic development. Analyses revealed that Missouri’s tax credit and incentive programs designed to encourage private investment have provided over 50,000 new jobs and leveraged \$4 billion in private business, real estate, and human resources investments in an average year. Each dollar of state credit expenditure is associated with \$30 in private investment for the 16 programs studied.¹⁰ The study determined that, for \$140 million in tax credits utilized in a single year, the state would generate additional state revenues with a present value of \$4.2 billion resulting from the increased economic activity created by the investment associated with the tax credits. Part of the state’s implementation of this life science strategy is the need to ensure that these tax credit programs are targeted on life science firms.

Moving forward, three key steps are recommended for advancing Missouri’s tax approaches in relationship to life science development:

1. Create a unique environment that supports the research and development efforts of emerging life sciences companies
2. Ensure a level playing field in application of sales and use tax for research and development activities
3. Undertake a competitive study of Missouri’s tax structure in supporting life science industry development.

Missouri has a key opportunity to set itself apart from other states and address a key need in becoming a strong home for emerging bioscience companies by creating a unique environment for supporting their research and development efforts.

It is recommended that Missouri be proactive in using its tax policies to offer a special package of incentives and tax exemptions for research and development to emerging life science companies for a period of five years. This package of R&D incentives would include

- **Exempting expenditures for equipment and supplies used in research and development activities by emerging life science firms from the state’s sales, use, and personal property taxes.** Currently, research and development purchases are taxed under the state and local sales tax, except for specific purchases that are pre-approved on a project-by-project basis by the Missouri Department of Economic Development up to an annual limit, and personal property taxes are applied to equipment used in research and development.
- **Establishing a separate transferable 25 percent R&D tax credit to support life science companies based solely on their level of current year research activity (enabling small firms to take advantage of R&D tax credits now practical only for larger firms).**

¹⁰ The Barents Group and KPMG LLP, *A Study of Missouri Tax Credits and Incentives*, prepared for the Missouri Development Finance Board, March 14, 2000.

- **Renewing the capital tax credit program for investors in emerging life science companies and targeting it toward investments for further research and development.**
- **Providing tax credits to back private institutional investment in a fund of funds only in the event of default.**

Missouri should ensure a level playing field in taxation by exempting sales and use taxes for research and development activities.

Sales and use taxes generally are intended to fall on the final consumption of taxable goods and services. Most states provide some kind of exemption for production activity in their sales and use tax statutes. In today’s advanced technology economy, production activity should be expanded to include research and development activities, given how integrally they are tied to future production. Many states do exempt R&D-related purchases from sales and use taxation, including Maryland, New Jersey, North Carolina, and Pennsylvania.

In Missouri, research and development purchases are taxed under the state and local sales tax, except for specific purchases that are pre-approved on a project-by-project basis by the Missouri Department of Economic Development up to an annual limit. Such a treatment of research and development activities is a significant disincentive for plant and life science companies. It treats research and development as a final good rather than as an interim process in creating final goods and services. It also is out-of-step with many other states with vibrant life science industry clusters.

Therefore, it is recommended that Missouri go beyond this strategy’s initial recommendation for emerging firms and fully exempt research and development from sales and use taxation.

Missouri should undertake a competitive study of its tax structure in supporting life science industry development.

The specific immediate tax reforms proposed previously point to a broader set of issues that Missouri needs to consider over time. It is important for Missouri to assess its overall approaches to taxation of life science companies, particularly addressing key issues of research and development activities that are the seed for future economic growth. It is particularly important for Missouri to examine how best to utilize tax incentives to promote life science industry development. A state-level task force should be formed by the Missouri Technology Corporation involving CFOs from plant and life science companies, major legal and accounting firms in the state that work with life science companies, and local economic development officials and business associations. This task force should consider the full range of tax structure issues in Missouri and compare the state with key competitors.

Resources Required: It is proposed that up to \$20 million in strategic tax benefits will be targeted to emerging life science companies and to exempting sales and use taxation on R&D expenditures.

Time Frame: This is an immediate priority.

Lead Organization: The MTC should take the lead on reviewing the state’s tax policies as they affect technology companies in general and life science companies in particular.

Action Four: Establish a Life Sciences Special Project Fund through MTC for large-scale, nonuniversity projects to retain, attract, and expand firms in the state.

If Missouri is going to actively work toward building its life science base, it needs a special life science development fund to attract and support large-scale development projects. This fund needs to be highly visible and able to be actively marketed. The terms of its assistance should be flexible and able to fit the particular needs of a project.

This fund might support such projects as building new facilities for relocating or expanding mature life science companies, developing new, nonuniversity research facilities, or attracting a major federal facility.

One state that has had significant success in operating a special economic development project fund, or “Sunny Day” program, is Maryland. Its special economic development project fund has been instrumental in retaining the manufacturing facilities of growing biotechnology companies, attracting a new facility of a foreign life science company, and retaining key headquarters and research operations of a long-standing life science company—it even provided matching funds to attract federal funding for a commercialization fund directed toward biomedical applications.

It is recommended that such a special project fund be created and funded annually for the life sciences in Missouri. MTC is viewed as a key agency to administer this special life science fund given its ability to help facilitate and evaluate such projects. The projects could be brought to a special legislative committee for approval, as is done in Maryland, to ensure that the project addresses a clear public purpose in support of Missouri’s economic development. This type of process also might address constitutional issues in Missouri.

If the use of direct government funds is not available, then it is proposed that targeted resources for major life science projects be established under the Business Use Incentives for Large Scale Development (BUILD) program. The Missouri Development Finance Board’s successful BUILD program has proven to be an essential ingredient for large-scale, single-tenant facilities for established, expanding companies.

Resources Required: It is proposed that the Life Science Special Project Fund receive \$40 million annually.

Time Frame: This is a mid-term priority.

Lead Organization: MTC.

Action Five: Develop a statewide image, marketing, and business development effort that builds on and supports current regional efforts to market Missouri as a center for the life sciences.

Missouri currently is not viewed as a leading center in the life sciences, although both St. Louis and Kansas City are beginning to be recognized as regions with considerable life science research institutions. Missouri needs to undertake a marketing campaign that will communicate to key audiences, both nationally and internationally, the depth and breadth of Missouri’s life science base and the unique opportunities and resources that the state provides for life science industries. The campaign also should testify to the level of commitment that the state’s public and private leaders are making to ensure that Missouri becomes a leading life science center.

St. Louis has already undertaken a full-fledged branding campaign marketing the St. Louis region as the Heart of the Multi-State BioBelt. St. Louis is targeting earned media in major bioscience and business magazines, organizing exhibits and events at key conferences, and pursuing both internal and external events.

It is recommended that the State of Missouri undertake a campaign that will build on St. Louis’s effort but that will market the life science assets of all regions of the state. The marketing effort should emphasize themes showing how the state is united in support of the life sciences and offers a rich, diverse base for the life sciences. Resources such as the presence in Missouri of the Donald Danforth Plant Science Center, the Midwest Research Institute, Stowers Institute for Medical Research, incubators, and the state’s universities should be highlighted.

Specific initiatives would enable Missouri to have a “best of breed” marketing and follow-on business development effort. These initiatives would include

- Developing a consistent and active media presence in major life science publications, involving infomercials such as special sections and announcements of Missouri company accomplishments and generally raising the awareness of Missouri’s branding in the life sciences. An active earned media campaign should be undertaken directly after release of this strategy. Having articles appear in newspapers and magazines nationwide describing Missouri’s plans to build its life science base will play a key role in changing the state’s image. The placement of such articles, however, will require an active public relations outreach to key publications and the active development of news stories.
- Creating a state-level life science marketing team to collaborate with regional groups in participating in industry trade shows, developing lead generation efforts, recruiting emerging life science companies associated with key faculty recruits, and developing and maintaining databases of Missouri relationships with out-of-state life science companies from across researcher and industry.
- Establishing an integrated, statewide, one-stop, life science company response team that will ensure quick turnaround on permitting, deal packaging, research partnering, and other needs of life science companies.
- Conducting trade missions in targeted domestic and foreign markets, focusing on companies with linkages to Missouri core competencies in the life sciences and undertaking reverse trade missions inviting foreign businesses to tour Missouri facilities.

Resources Required: It is estimated that \$5 million annually will be required for this marketing and business development effort.

Time Frame: This is an immediate priority.

Lead Organization: Missouri Department of Economic Development.

Action Six: Initiate a statewide education campaign on the benefits and importance of the life sciences to the state’s economic future.

For this life science strategy to be successfully achieved, various groups and organizations across the state must come together to support its implementation. But, to do this is not easy or simple. The stakeholders will need to be committed to this effort for the long term; states do not build life science bases overnight. And it will require a considerable degree of collaboration and

connectivity among the various entities willing to work over many years for the common good of the state.

When studying successful technology communities, it becomes clear that success takes time. Silicon Valley and Route 128 trace their origins in electronics to the 1950s and in life sciences to the 1970s. Research Triangle Park represents a 50-year strategy that only recently has found its footing in the life sciences and still is working to develop full capability in the entrepreneurial sector. Only Maryland has been able to position itself as a major player in the life sciences in less than 25 years, and it still took them 12 to 14 years while having the advantage of being home to both NIH and USDA. Perseverance and recognition of long lead-time is necessary; but, a mobilized, committed set of community leaders and institutions is absolutely essential.

The decision to invest the resources to make Missouri a leader in the life sciences will be difficult given the state’s fiscal situation. The support and involvement of key community leaders will be essential to mobilizing support for the necessary financial investments and to educating the citizenry on the benefits that will be achieved by growing the state’s life science sector.

An internal education campaign should be initiated to increase Missouri policymakers’, legislators’, and residents’ knowledge and understanding of the life sciences, the role they play in Missouri’s economic future, the opportunities they provide for them and their children, and the role new discoveries and inventions will play in their lives. It will be particularly important to brief legislators, given the fact that there will be a large number of new legislators due to term limits.

It should be aligned with the branding and marketing campaign, but it will require a distinct set of activities. Potential activities include public service announcements, a life science ambassador program to reach schools and local civic organizations, regular monthly and quarterly events, and an Internet Web site to keep citizens informed of developments in the life sciences.

Resources Required: It is anticipated that the education campaign could be undertaken with existing resources, including those of Missouri’s higher education institutions.

Time Frame: This is mid-term priority.

Lead Organization: MTC, working in partnership with regional development organizations.

STRATEGY FOUR: INCREASE THE CONNECTIVITY BETWEEN LIFE SCIENCE EMPLOYERS AND EDUCATORS AND ENCOURAGE STUDENTS AND WORKERS TO PURSUE CAREERS AND OPPORTUNITIES IN THE LIFE SCIENCES.

Technology is driving a large proportion of the growth in the world economy today. It is being embedded in a new generation of products and devices and is being used to dramatically increase the productivity and profit margins in traditional markets and industries. In addition, rapidly changing technologies, completion of the Human Genome Project, and emerging new fields of study such as bioinformatics and proteomics provide an opportunity to explore new fields of inquiry. This exciting technological revolution, however, has serious consequences for work-force development and associated human resource issues.

The overriding goal of most states is to create high-wage jobs in technology-based businesses to increase per capita income and improve citizens’ standard of living. Building the technical skills of the existing and future workforce is critical to accomplishing that goal. The availability of an educated, highly skilled workforce is a prerequisite for a knowledge-based economy. Those states that can offer a steady supply of skilled workers in these emerging areas have a comparative advantage in developing, attracting, and growing their life science industry. They also permit their research infrastructure to have a sufficient talent pool from which to draw for its scientific personnel.

A report by the National Governors’ Association noted that “the traditional approaches to worker preparation are rooted in the supply side of the labor market, building the skills of job entrants with minimal input from employers or regard for how these skills are further developed and used in the workplace. A wide gap has emerged between the public training and employment services system and the human resource development strategies and operations of firms. There is growing consensus that the nation’s public workforce development system needs to:

- Be more closely aligned with the standards and practices that are part of firms’ internal human resources systems;
- Move beyond initial job preparation and placement to include ongoing skill development and career progressions for employed workers;
- Provide post-employment training closely linked to employers’ needs; and,
- Create career pathways to further education and upward mobility for all workers.”¹¹

Improving the effectiveness of the workforce development system will require adopting a “demand-side strategy” that will build on employers’ economic interests. Overall, the life science industry has not experienced the problems of an insufficient labor pool, as have other technology industries. Instead, its labor issues have been centered on finding individuals with the skill sets demanded by industry.

Tactics

As Missouri’s life science industry develops, care must be taken to ensure an adequate supply of technically skilled workers. Industry will grow where the talent is located; therefore, if Missouri has a sufficient life science talent pool in the future, the region will have a significant advantage. The following key tactics will help position the region to accomplish this:

- Higher education institutions that can quickly adjust their curricula to take into account changes in disciplines, fields of study, and multidisciplinary inquiry are more likely to graduate students with education in fields of extreme interest and short supply in the industry. Furthermore, such graduates can help support and further develop Missouri’s research enterprise.
- Emphasis should be directed at retaining individuals who have developed needed skills in Missouri’s institutions of higher education, in addition to attracting Missouri’s best and brightest to enter the field.
- Addressing the life science pipeline of future workers is critical. A focus is required both on K-12 education and on technician-level education in community colleges, two areas from

¹¹ National Governors’ Association, *State Strategies for the New Economy*, 1999.

which the life science industry traditionally has not drawn its workforce but likely will in the future.

Actions for Strategy Four

- **Action One:** Improve math and science education at the K-12 level by exploring innovative methods to promote excellence, thereby increasing opportunities for students in the life sciences.
- **Action Two:** Provide incentives to higher education institutions to work with industry to review and adopt new multidisciplinary curricula, including offering related degrees and certificates, and provide innovative workforce programs in the life sciences.
- **Action Three:** Initiate a yearly workforce survey through MOBIO of the state’s life science industry to assess demand for various skills, positions, and careers and convey this information to education and workforce providers.
- **Action Four:** Offer year-round internships and co-op opportunities to higher education students in firms, nonprofits, and other life science organizations as well as summer opportunities for residents going outside the state for their education.
- **Action Five:** Support, market, and expand the Advantage Missouri Program, the state’s scholarship program that includes students majoring in the life sciences, for individuals that stay in the state upon graduation.

Action One: Improve math and science education at the K-12 level by exploring innovative methods to promote excellence, thereby increasing opportunities for students in the life sciences.

A high-quality public education system is a prerequisite for growing a technology-based economy. A recent study¹², which examined student achievement data from the National Assessment of Educational Progress (NAEP), found that

- Student achievement scores are higher in states with higher per-pupil expenditures
- Lower student-teacher ratios in the early elementary grades can significantly improve scores
- Adequacy of instructional education resources at the classroom level has a positive impact
- Higher prekindergarten participation in educational programs has a positive impact
- Lower teacher turnover helps.

If Missouri is to compete in today’s knowledge-based economy, the state must commit to investing sufficient resources in K-12 and holding schools accountable for excellence. Currently, \$1,036 is being spent per capita on elementary and secondary education in Missouri.¹³ This ranks the state 40th in the nation in educational expenditures at the K-12 level.

Governor Holden addressed this issue in his 2002 State of the State Message when he outlined a series of reforms that should be undertaken to improve the K-12 Missouri System, such as:

¹² Grissmer, D., Flanagan, A., Kawata, J., and Williamson, S. *Improving Student Achievement. What State NAEP Test Scores Tell Us.* Santa Monica, CA: RAND Education, 2000.

¹³ Snyder, Thomas D. *Digest of Education Statistics, 2001.* NCES 2002-130, Washington, DC: U.S. Department of Education, National Center for Education Statistics, 2002.

- Reduction of class size in problem areas to allow teachers more time for individual student attention
- Preschool and full-day kindergarten to enable young students to get off to a good start
- Hiring teacher specialists to provide additional attention to those subject areas where improvement is necessary to address poor achievement
- After-school programs, summer school programs, and one-on-one tutoring to provide under-performing students with the help they need to improve their chances for success
- Reduction of school size or the establishment of schools within schools or alternative schools to improve the learning environment.

In addition to adequately funding education and holding schools accountable for performance, a special effort must be made to improve math and science education at the K-12 level. Engaging students in scientific or technological careers is seen as a difficult challenge across the country. It is recognized that a child should be introduced at an early age to mathematics and the sciences; otherwise, he or she will quickly fall behind and be unprepared to enter collegiate engineering or scientific curricula. Results from the Missouri Assessment Program showed that 37 percent of third-grade students in the state were at a proficient or advanced level in math. However, by the time they reached the 10th grade, only 10 percent of Missouri students were at these skill levels.

This poor performance was the catalyst for creating the Missouri Mathematics Academy (see text box). Innovative initiatives such as the academy need to be developed, supported, and grown within the state if real change and improvements are to be realized.

The Missouri Mathematics Academy

The Missouri Mathematics Academy, launched in the summer of 2001, is an innovative pilot program that focuses on the ongoing professional development of Missouri's math teachers. The Mathematics Academy trains middle school math teachers in best practices curriculum with the intent that in eight years Missouri middle school students will lead the nation in math proficiency.

The curriculum content is based on industrial needs for mathematical skills, especially the needs of the life sciences, information technology, and advanced manufacturing sectors, thereby mirroring the needs of industry by illustrating the relevance of mathematics in today's technological society. The Academy focuses on professional development of the teachers by concentrating on content expertise and instructional practices that will help them move from teaching mathematics as "calculation" to incorporating more mathematical reasoning and algebraic thinking. The state-of-the-art teaching techniques are designed to help Missouri students develop greater mathematical reasoning skills and teach them how to apply those skills to real-world situations.

The inaugural session of the Missouri Mathematics Academy took place at Fort Leonard Wood, with 40 teachers from throughout the state participating. Educators are matched with coaches and commit to receive two years of ongoing professional training following their participation in the sessions. Activities at the summer session included applying math to GPS surveying courses, navigation on the Mississippi River, and other activities provided by the U.S. Army. The academy is expected to train 200 teachers in 2002 and 400 more in 2003.

The K-16 Task Force and others are extensively studying the issues that currently face the Missouri K-12 system, and their efforts should be supported. As these various studies with their subsequent recommendations are developed, potential initiatives to improve math and science

education should be examined. Included among areas to be examined and further reviewed are the following options:

- Providing special recognition for high school graduates who complete four years of math and four years of science and expanding math and science (including biology) requirements for high school graduation over time.* The Education Commission of the States has developed data regarding the level of educational attainment that all 50 states require of their high school students to graduate. The number of units a state requires for graduation is a measure of the potential aptitude their students will possess in the various technological fields. The majority of states require completion of four units in language arts/English to graduate. Among the states that mandate requirements in social studies, math, and science, the average unit requirements are: social studies, three units; math, two units; and science, two units. However, there is clearly a trend among the states to increase the required units in math and science. Currently, Missouri requires only two units each in math and science. The state should consider increasing its math and science requirements to at least three units each, if not four, which would be equivalent to the current English requirement. Of the four potential science requirements, two should be in biology. This additional education in the technological fields will enable Missouri students to be much more prepared for either advanced education or employment in the New Economy industry sectors. Understanding that such a change will need to be implemented over the long term, the state should consider establishing a mechanism, such as a special diploma, to recognize students who choose to complete four years of math and science as part of their high school curriculum.
- Developing programs and initiatives at the middle school level designed to interest students and parents in math and science.* It is generally agreed that students choose in middle school to take the necessary math and science classes to prepare them for advanced work in scientific fields. Therefore, it is very important that life science careers are promoted so that students can see the benefits of pursuing a scientific course of study. One activity would be to work collaboratively through the science- and technology-related teacher associations to present exciting role models, mentors, speakers, and other resources to the students and engage them in practicum that fit their life and learning styles. Another key activity would be to work with school guidance counselors to help them understand the range of career opportunities presented by life science fields and the types of schooling required, and, possibly, to include more state financial support to give guidance counseling a stronger set of

The Connecticut BioBus

The Connecticut BioBus, sponsored by the biotechnology industry association CURE, is a new program that began in the 2001-2002 academic year. The BioBus is a mobile, state-of-the-art, fully equipped biotechnology laboratory that brings enriching educational experiences in biotechnology to middle and high school students across the State of Connecticut.

A BioBus visit consists of between one and four pre-programmed 2-hour experiments designed to stimulate students' biological and intellectual curiosity. Teachers are given curriculum materials prior to the BioBus visit and are required to attend a preparatory workshop or training session to be trained for pre-lab and post-lab activities as well as for assisting in the BioBus experiment(s). When the BioBus is in their locale, visiting scientists and representatives of sponsoring companies are on board, serving as role models and scientific experts, with particular emphasis on demonstrating the “real-life” applicability of the BioBus experiments. In addition, the visiting scientists answer questions about career opportunities and maintain links as a science education resource for the teachers.

functions in the public school system of the state. In addition, after-school programs and summer camps can interest students in math and science and provide career awareness experiences.

- *Using distance education technology to bring high-quality math and science instruction to students in all parts of Missouri.* While it may be unrealistic for every community in Missouri to be able to provide advanced biological science and math courses, students should be given the opportunity to take such courses via distance learning technology.
- *Instituting a differential pay scale or incentive system that allows science and math teachers to be more highly compensated.* In today’s market, it is extremely difficult to recruit math and science teachers given the opportunities available to people with scientific and technical degrees. Yet, improving math and science education will require the ability to recruit teachers with math and science credentials. Consideration should be given to providing a salary differential or other financial incentives for math and science teachers.
- *Converting a greater proportion of vocational education programs into “tech prep” programs in fields such as laboratory technician operations.* Academic curricula need to be modernized around technology-intensive career opportunities. As the state considers further investments in vocational-technical education, it should ensure that life science-related skills development becomes a major thrust of the vocational system, driven in close collaboration with industry.

Vocational-technical high schools should be modernized in curricula, equipment, and instructors for 21st century skill training. Also, vocational high schools need to offer a clear path after high school to community colleges through an invigorated “2+2+2” program. In St. Louis, a promising partnership has developed between West Technical High School and St. Louis Community College’s Biotechnology Program located on its Florissant Valley Campus.

Maryland – Montgomery College, Montgomery Public Schools, and the Universities at Shady Grove (USG): Early Placement and University Partnership

Montgomery College, the Community/Technical College for Montgomery County, Maryland, has developed relationships with the Montgomery County Public Schools and the universities at the Shady Grove Life Science Center to offer a 2+2+2 program of technical education. Beginning with the last two years of high school, the program continues with two years and an associate’s degree from Montgomery College and offers the option of completing with two final years for a bachelor’s degree.

The first phase, the Montgomery County Public Schools (MCPS) Tech Prep program, allows high school students to receive college credits for grades of B or better if they major in the corresponding program at Montgomery College. As of the 2001-2002 academic year, students are eligible to receive credit in one of 22 college programs, including biotechnology. The high school biotechnology program is housed at the Thomas Edison High School of Technology, and offers intensive laboratory experience, interaction with scientists and technicians from local research facilities and firms, and leads for summer and college internship opportunities.

Once the student completes the second phase and earns an associate’s degree from Montgomery College, he or she may choose to continue toward a bachelor’s degree at the Shady Grove Center. There are 11 University of Maryland System institutions involved in the partnership.

BioTechnical Institute of Maryland

The BioTechnical Institute was created in 1998 to address the growing need for qualified and specially trained lab technicians in Maryland’s rapidly expanding biotechnology industry. It does so with a variety of programs designed to increase the state’s pool of credentialed bioscience and pharmaceutical technicians:

- Customized training for specific laboratory skills
- Laboratory accreditation courses (including GMP, GLP, and Safety)
- Curriculum design in coordination with bioscience firms and state universities and colleges to provide continuing education and skill validations
- Customized applicant pre-screening for bioscience firms.

The training and accreditation programs are free of charge to participants who qualify based on high school (or GED) record and aptitude assessments. The BioTechnical Institute, organized as a not-for-profit corporation, is supported by the Abell Foundation, MdBio, Maryland state and local agencies, and the bioscience community.

Maryland—The Johns Hopkins University: Master of Science in Biotechnology

The Johns Hopkins University offers a master of science in biotechnology as a part-time graduate program designed for professionals already working in the field, as well as for engineers, educators, scientists, and lawyers wishing to gain formal knowledge in biotechnology. The program includes 10 courses, and prerequisites include either an undergraduate degree in the natural sciences or engineering, or two semesters of college chemistry and two semesters of organic chemistry. Concentrations in bioinformatics and biotechnology enterprise are currently offered.

A certificate in biotechnology enterprise is available for those desiring a deeper understanding of the business aspects of biotechnology without completing an entire master’s degree program—the certificate requires six courses.

- *Developing magnet high school programs is another approach that has been successfully adopted by states for keeping top students involved in science and technology fields through enriched curricula.* Examples include Virginia’s Thomas Jefferson High School for Science and Technology and the magnet programs at Montgomery County in Maryland.
- *Exploring ways to develop and expand life science curricula, equipment, and instruction in the high schools and integrate these costly resources across both the vocational and traditional high schools.* Given the rapid rate of change in this field, it is unrealistic to expect that expensive labs and related instruction can be replicated in all schools. Schools must find creative ways to fully utilize these technologies for all students, including the college bound and vocational students, as well as adult students who can use school facilities in the evening hours.

Resources Required: To be determined.

Time Frame: Short-term.

Lead Organization: Department of Elementary and Secondary Education.

Action Two: Provide incentives to higher education institutions to work with industry to review and adopt new multidisciplinary curricula, including offering related degrees and certificates, and provide innovative workforce programs in the life sciences.

For Missouri to be a leader in the life sciences, its higher education institutions must constantly innovate, ensuring that the necessary interdisciplinary programs are in place to educate, train, and graduate the future workforce as well as to keep the existing workforce up to date through life-long learning efforts. Rapid changes in recent years have already created such fields as bioinformatics, proteomics, biomaterials, and bioelectronics. For the state to remain competitive, it must have agile higher education institutions that can quickly respond and change curricula and program offerings.

A consensus emerging among those working in the education and training field is that improving the effectiveness of the workforce development system will require adopting a “demand-side strategy,” built on a market-driven approach that builds on employers’ economic interests. Critical to these efforts are

- Building the bridges to industry needs through ensuring skill standards for education and training that meet industry requirements
- Having educational institutions focus on creating closer connections between students and industry
- Creating much closer applied-research collaborations between educational institutions and industry.

Georgia’s Intellectual Capital Partnership Program

Georgia has been very active in the field of technology workforce development through the Intellectual Capital Partnership Program (ICAPP). ICAPP was created to meet the immediate needs of new and expanding technology companies for workers, including the bioscience industry. ICAPP trains workers for high-demand technology jobs whenever a low supply of qualified employees exists, and leverages the resources of Georgia’s colleges and universities to provide customized, accelerated educational programs to meet the specific needs of employers. ICAPP achieves its mission through five programs:

- ICAPP Access products provide user-friendly, “one-stop shop” access that makes the resources of the University System easily available to Georgia businesses.
- ICAPP Advantage is a direct economic development incentive that helps companies meet immediate human resources needs. Through ICAPP Advantage, Georgia’s public colleges and universities expedite the education of highly skilled workers to meet a company’s workforce needs for knowledge workers in high demand but low supply.
- ICAPP Needs Assessment works to match the programs of Georgia’s colleges and universities with the needs of Georgia’s current and prospective employers and industries. This “supply and demand” approach, while fundamental in business, is on the cutting edge of higher education.
- ICAPP Strategic Response Initiatives create model academic programs to address the shortage of knowledge workers, such as information technology professionals.
- ICAPP Regional Programs support collaborations among University System institutions and other public-private organizations to find regional answers to specific regional economic development needs.

ICAPP has been used and can continue to be tapped to meet the workforce needs of the state’s bioscience companies. For example, ICAPP provided assistance to Monsanto by educating 20 team leaders for a new facility in Augusta that will produce bovine somatotropin, a synthetically produced hormone that increases milk production in cows. This facility will be the largest protein fermentation production facility in the world. During a second phase, ICAPP expects to educate 130 unit specialists in chemistry, biochemistry, and microbiology.

Data from the National Center for Education Statistics show that, during the 2000-2001 academic year, Missouri graduated 12,135 students in bioscience-related disciplines, with the vast majority of those in clinical fields. Among the benchmark states, Missouri had the second-highest number of total bioscience degrees per 100,000 capita, at 217 versus 227 for Pennsylvania. However, compared with the bioscience workforces in each state, Missouri produces fewer bioscience research graduates per existing bioscience job than all but two of the benchmark states.¹⁴ Therefore, at its present rate, it is likely that Missouri will be unable to keep up with industries’ need for skilled workers in the state.

Missouri’s higher education institutions should examine how they can “fast track” changes in their curricula to best position the region to secure sufficient personnel in the identified core competency life science areas, thereby ensuring an adequate supply of workers to local employers. Key to Missouri’s successful competitions with other states is having a much better talent pool available in the new and emerging life science multidisciplinary fields. Higher education can undertake this without necessarily requiring substantial new resources.

Resources Required: \$250,000 to \$750,000 and realignment of existing dollars to enhance the academic priority of working with industry.

Time Frame: Immediate.

Lead Organization: Department of Higher Education, working in partnership with Missouri’s institutions of higher education and life science industrial base.

Action Three: Initiate a yearly workforce survey through MOBIO of the state’s life science industry to assess demand for various skills, positions, and careers and convey this information to education and workforce providers.

To enable academic institutions to fine-tune their efforts and ensure that they are responsive to industry, an annual industrial survey of life science education and workforce training needs should be conducted. Survey participants should include both employers and employees, particularly those who have recently graduated from a Missouri educational institution. This survey tool can meet two important needs. First, it can serve as an informative study of how academia is meeting the needs of industry in respect to the workers it is producing. Secondly, it can help to quantify the demand for high-skill, high-wage jobs in the state, thereby acting as a marketing component of the growing life science base.

A few state trade associations are undertaking similar activities in an attempt to better understand the workforce needs of their industrial base. For instance, the New York Biotechnology Association (NYBA) publishes and distributes surveys, guides, and industry studies to educate and inform citizenry about the bioscience industry. In particular, NYBA recently received grant funding for programs aimed at meeting the workforce needs of biotechnology firms. Initial activities will include an industry workforce survey. NYBA is a not-for-profit trade association dedicated to the development and growth of biotechnology-related industries and institutions based in New York State, and to strengthening the competitiveness of New York State as a premier global location for biotechnology/biomedical research, education and industry.

¹⁴ National Center for Education Statistics, COOL (College Opportunities On-Line) Data; Dun & Bradstreet *MarketPlace* (employment level); United States Census Bureau (population), Battelle calculations.

Resources Required: \$250,000 annually.

Time Frame: Immediate.

Lead Organization: MOBIO.

Action Four: Offer year-round internships and co-op opportunities to higher education students in firms, nonprofits, and other life science organizations as well as summer opportunities for residents going outside the state for their education.

One way to build and retain talent is to establish personal relationships with students while they are still in school. Experience shows that efforts such as internships and co-ops can be effective in increasing the retention rate of students upon graduation. Missouri firms need to increase the level and scale of efforts to increase college students’ knowledge and awareness of career opportunities. By becoming more familiar with employers in the state, a greater number of graduates will be more likely to stay in Missouri upon graduation.

A structured internship/co-op initiative could provide a matchmaking service to link life science firms with students at Missouri’s higher education institutions. One example of this type of activity already being undertaken is the Collaborative for Applied Experiences in Science (CAES) at the University of Missouri at St. Louis.

Particular emphasis should be focused on placing Missouri young people who leave the state to pursue their education in summer internships with Missouri firms. According to the National Center for Education Statistics, approximately 5,500 high school students leave Missouri for college each year.¹⁵ This out-migration represents an important component of the state’s potential future workforce. To increase the likelihood of these individuals returning to Missouri upon graduation from their out-of-state academic institutions, efforts need to be made to maintain connections with these youths, especially those in life science fields. One way to maintain these connections is to identify and reach out to those

St. Louis—Collaborative for Applied Experiences in Science (CAES)

The Collaborative for Applied Experiences in Science (CAES) is designed to match bright and capable undergraduate students with scientists, mathematicians, and engineers at St. Louis science-based corporations and institutions of higher education. To be eligible, students must be graduates of precollegiate research programs, must be currently enrolled in an undergraduate program, and must have completed at least one full year of a mathematics, science, or engineering program. CAES, hosted by the University of Missouri at St. Louis, posts student applications and asks corporate participants to search for suitable internship candidates. CAES is funded by the University of Missouri at St. Louis, along with the E. Reuben and Gladys Flora Grant Charitable Trust-Commerce Bank and Helen C. Bauer Trustees, in cooperation with the St. Louis Regional Chamber and Growth Association.

Drexel University’s Ultimate Internship

Drexel University in Philadelphia has long been known for its co-operative education/internship programs. "The Ultimate Internship" is a key component in Drexel's career-oriented majors, and it is part of a larger program of career preparation for all students. A co-op is an extraordinarily valuable enhancement to academic studies, and it sets Drexel apart from other universities. It is an option or a requirement in almost every undergraduate major. Students graduate with up to 18 months of career-related experience gained in up to three different jobs. Drexel has established relationships with over 1,600 hundred companies and have almost 5,000 co-op opportunities available for its students.

¹⁵ Snyder, Thomas D. *Digest of Education Statistics, 2001*. NCES 2002-130, Washington, DC: U.S. Department of Education, National Center for Education Statistics, 2002.

Missouri youths who leave the state for college with summer internships with life science industry. This effort could be a stand-alone effort or coupled as a feature of the statewide internships/co-op effort. If possible, this summer internship connection should begin as soon as they leave for college; certainly, it should be aggressively promoted in the summer before their senior year.

Across the nation, individual educational institutions have achieved excellent results in creating, within their own schools, a strong, enduring linkage with industry that transcends how students are educated and prepared to enter the workforce. Two notable examples are Northeastern University and Drexel. At both Northeastern and Drexel, science majors are required to complete co-ops/internships, which are typically full-time and paid positions. At Drexel, about one in five students is involved in co-ops at any one time, and at Northeastern nearly one in three. Nearly one in three students at each of these institutions is hired by a past co-op employer. Northeastern has structured co-op preparation activities, either on a group or individual basis with the faculty coordinator, to develop job skills, practice goal setting, hone decision-making skills, and explore career options. A reflection phase is included following the co-op to analyze the experience, produce final works or projects arising from the co-op, and “debrief” the student.

It is proposed that Missouri encourage this focus on practical education for life science skills across all higher education institutions by supporting co-ops and internships between students and companies. These co-ops and internships should not be viewed as a supplement to the education training, but as an integral part of the curriculum. Active training collaborations between educational institutions and life science businesses in Missouri should underpin these co-ops and internships through use of industry professionals to serve as adjunct faculty helping to teach courses and active industry involvement in the curriculum to meet the demands of the workplace. The state needs to develop its co-op and internship programs to encourage students in the state to stay upon graduation; to entice students leaving Missouri for college to come back; and to otherwise increase partnerships between industry, higher education, and students.

As an incentive for a rapid scale-up of these efforts, the state should provide three-year grants that educational institutions can apply for to pay for the operational costs of life science internship and co-op programs. These funds can be used for employer outreach, new curriculum development, and assistance to students. It is expected that the benefits of this focus on “practical life science education and training” will go well beyond the effective training of graduates. They also will create a strong linkage between students and Missouri businesses that can ease the transition into the workforce, as well as infuse a deep working partnership between industry and higher education in upgrading curricula and creating innovative programs that serve students.

Many **benefits** could accrue from an enhanced internship/co-op function, including the following:

- Increasing the perceived value of a Missouri education, to both prospective students and parents. Parents increasingly desire evidence that their child is receiving both a theoretical and practical set of experiences and an education that will prepare him or her ultimately for the world of work.
- Providing important real-world feedback to curriculum and instruction, helping to ensure that course content, programs of study, and laboratory experiences are high quality.
- Increasing graduation retention rates.

Resources Required: \$500,000 annually.

Time Frame: Mid-term.

Lead Organization: MTC in partnership with universities and industry participants.

Action Five: Support, market, and expand the Advantage Missouri Program, the state’s scholarship program that includes students majoring in the life sciences, for individuals who stay in the state upon graduation.

To develop the pipeline of skilled workers that the life science industry sector will need to prosper and grow in the state, Missouri’s institutions of higher education must be committed to providing the graduates who will be in demand over the next five years.

Missouri already has initiated an effort to retain the very best and brightest high school students by offering scholarships through the Advantage Missouri Program. The Advantage Missouri Program provides financial assistance to students in undergraduate programs of study leading to employment by Missouri businesses and industries in high-demand occupational fields. These fields include biomedical/biotechnical, advanced manufacturing, and information technology fields. The Advantage Missouri Program is a loan forgiveness program designed to address Missouri's workforce needs. A student enrolled in an academic program related to one of the designated high-demand fields may apply for a loan. After graduation, the student has one year to obtain employment in the designated high-demand occupation in Missouri. The student will have one year of loans forgiven for each full year of employment in the designated high-demand occupational field in Missouri. The student must repay the loan funds with interest if the employment obligation is not fulfilled.

However, based on the Governor's recommended budget for the Advantage Missouri Program and current budget limitations, only renewal students will be considered for Advantage Missouri awards during the 2002-2003 academic year.

It is proposed that the scholarship program’s funding be appropriated in the current budget year and expanded in future years as demand increases. It is important for the state to offer incentives to graduates from Missouri’s high schools to stay and obtain their higher education in the state. Refocusing existing state dollars on efforts to attract and retain the region’s most outstanding graduates will pay dividends many times over, since it is more likely that these outstanding graduates will stay in Missouri after they complete their education. Recent studies suggest that where students go to college impacts where they reside afterward.

It is important to note that the success of this effort will depend on an adequate supply of high school graduates with sufficient math and science skills to pursue a life science degree (refer to the detailed discussion under Action One).

Resources Required: Reinstate funding for future years and, as the demand for the program grows in the future, allocate additional resources.

Time Frame: Mid-term.

Lead Organization: Missouri Department of Higher Education.

Implementation

The life sciences hold great potential for the State of Missouri. The industry is expanding rapidly, and Missouri is positioned to continue to grow its life science research base and capitalize on its commercial potential. Competing for leadership in the life sciences, however, will not be easy and will require significant commitments from Missouri’s public, nonprofit, and private sectors. Missouri is fortunate in that (1) its two major metropolitan areas, St. Louis and Kansas City, have committed to developing their life science sectors and (2) other regions of the state, such as St. Joseph and Rolla/Springfield, have developed strengths in key life science areas. For these initiatives to succeed and for their impact to be felt across all regions of Missouri, the State of Missouri must commit both leadership and resources to making Missouri a leader in the life sciences.

Unless Missouri implements the strategies and actions outlined in this report, the state cannot hope to compete with existing leading life science centers or with those states and regions committed to developing their life science sectors and willing to make the necessary investments.

The proposed actions taken as a whole represent a comprehensive approach needed to grow the life sciences in Missouri.

PRIORITIES

Nine of the 20 actions should be considered immediate priorities to be addressed over the next two years:

1. Release funding and eliminate matching requirements for legislatively approved capital projects of the University of Missouri System.
2. Create a Missouri Life Science Opportunity Fund that would invest in the research base of the state.
3. Revise and expand the mission of the Innovation Centers to provide in-depth entrepreneurial assistance services, incubator operations, research park development, and the establishment of satellite operations.
4. Create and invest (through appropriations or tax credits) in Technology Development Funds.
5. Create a large-scale (\$150 million to \$200 million), Missouri-based “fund of funds” to serve as a vehicle for institutional investment of all kinds, including public pension funds, in private equity funds that in turn invest in life-science start-ups and in the real estate necessary to house them.
6. Make changes in Missouri’s tax structure to provide incentives for the growth and development of the state’s bioscience base.
7. Develop a statewide image, marketing, and business development effort in concert with regional efforts underway.

8. Provide incentives to higher education institutions to work with industry to review and adopt new multidisciplinary curricula, including offering related degrees and certificates, and provide innovative workforce programs in the life sciences.
9. Initiate a yearly workforce survey through MOBIO of the state’s life science industry to assess demand for various skills, positions, and careers and convey this information to education and workforce providers.

ORGANIZATION AND STRUCTURE

Kentucky Creates Office of the Commissioner for the New Economy

The Kentucky Innovation Act of 2000 created a new Office of the Commissioner for the New Economy in the Cabinet for Economic Development. The duties of the Office for the New Economy, as stated in the legislation, include undertaking a strategic technology capacity initiative, developing a knowledge-based economic strategy, assisting the Economic Development Cabinet in recruiting research and development companies and attracting high-tech research and development centers; supporting the growth and creation of knowledge-based innovative companies; building and promoting networks of technology-driven clusters; administering the high-tech construction pool and the high-tech investment pool authorized in the Act; and recommending projects to the Kentucky Economic Development Finance Authority for funding.

The Office for the New Economy has just released *Innovation Kentucky: A Strategic Plan for the New Economy*. The strategy proposes initiatives in the areas of research and development, commercialization, and workforce.

Implementing the Missouri life science strategy will require both staff and resources. One or more entities must be designated to take the lead on implementing the various initiatives proposed in the strategy, and an organization must be given responsibility for overseeing overall implementation. States use three models of organizations that to implement technology-based economic development programs. They can be housed within an existing state agency, established as an independent state agency or commission, or lodged in a private nonprofit corporation (see Appendix C for a description of organizational models in different states).

Currently, the Office of Science and Technology within the Missouri Department of Economic Development administers Missouri’s existing technology development programs. These include the Innovation Centers and Missouri Enterprise, Missouri’s MEP Program. The department’s Office of Business Finance and Office of Business Development provide assistance to technology companies seeking financing or other business assistance services. The department currently has one full-time employee devoted to technology development.

Missouri also has a private nonprofit corporation created to foster the growth of Missouri’s technology economy. Established in 1994, the Missouri Technology Corporation (MTC) is dedicated to creating a stronger Missouri economy through the development of science and technology; promoting business modernization through transfer of science, technology, and quality improvement methods; and enhancing the productivity of Missouri business.

MTC is a 501(c)3 nonprofit organization with a Board that includes the Director of the Department of Economic Development, the President of the UM System, a member of the Senate and the House, and 11 members appointed by the Governor. MTC advises both the Department of Economic Development and the Governor regarding business development opportunities related to new technology and products.

In the past, MTC has not had program responsibilities. Rather, MTC has operated in more of an advisory capacity and acted as a catalyst to promote public/private partnerships. Recently, efforts have been initiated to place programs and funding under the direct control of MTC.

Several alternative approaches could be taken to implement Missouri’s life science strategy. First, the Office of Science and Technology in the Department of Economic Development could be expanded and given responsibility for implementing the strategy and undertaking many of the proposed strategies and actions. This would follow the model of states like Ohio and Utah in which the state development agency has primary responsibility for implementing the state’s science and technology programs. The drawbacks of this approach are that, given Missouri’s fiscal situation, it will be difficult to add employees to the state payroll and state government is prohibited from taking some of the actions proposed in the strategy. In addition, a mechanism would need to be put in place to ensure that the private sector is driving the initiative.

Implementation Options

- Expand the Office of Science and Technology within the Department of Economic Development
- Create the position of Governor’s Science and Technology Advisor and establish a new Governor’s Office of Science and Technology
- Create the position of Governor’s Science and Technology Advisor and have the Science Advisor serve as the CEO of the Missouri Technology

constitutional prohibitions on state government activity. For MTC to serve this role, it would need both staff and resources. The best alternative for Missouri might be to combine the second and third options by having a science advisor who would also serve as the CEO of MTC.

Kansas Technology Enterprise Corporation

The Kansas Technology Enterprise Corporation (KTEC) was established in 1987 by the Kansas legislature to promote advanced technology economic development. KTEC is a quasipublic corporation, which is overseen by a Board of Directors appointed by the Governor and legislative leadership. The board reviews the investment recommendations of the KTEC president and staff and is responsible for policy development. The board includes two members of the state Senate, two members of the House of Representatives, and the Lieutenant Governor. The state’s universities and private sector also are represented. The president of KTEC, who is hired by the board, serves as an informal advisor to the Governor and legislature.

KTEC awards grants for joint industry-university research programs through its Applied Research Matching Fund; supports Centers of Excellence at Kansas universities; manages the state’s Experimental Program to Stimulate Competitive Research (EPSCoR); and supports a network of Innovation and Commercialization Centers, each of which operates its own seed fund.

Second, the Governor could appoint a Science Advisor and create an Office of Science and Technology within the Governor’s Office. Again, this approach would have the same limitations as enhancing the Department of Development’s staff.

Third, MTC could serve as the vehicle to oversee and implement the life science strategy. MTC would have the advantages inherent in being independent of state government, i.e., the ability to be more market-driven and flexible and not constrained by state salary requirements or

Studies of strategic planning suggest that a critical success factor is the presence of a champion who has the ability to bring together key stakeholders and mobilize various institutions to implement the strategy. ***It is proposed that the Governor create the position of Governor’s Science and Technology Advisor*** and lodge responsibility for overseeing implementation of this strategy with this position. The Science and Technology Advisor should be a nationally recognized scientist who has served in senior positions within both academia and industry. It is recommended that the Advisor hold a Ph.D. in the life sciences and have an outstanding record of accomplishment in the plant and/or life sciences. The appointment of a Governor’s Science and Technology Advisor will be a visible sign by the Governor that he is committed to making Missouri a leading center of the life sciences in the Midwest.

The Science Advisor would

- Offer ongoing advice, direction, and policy guidance to the Governor and the legislature on issues related to the science and research capacity of Missouri.
- Work with the state’s research and higher education institutions to strengthen the state’s research base and capabilities.
- Offer ongoing advice, direction, and policy guidance to the Governor and the legislature on issues affecting technology-based businesses and connections to the state’s R&D anchors in higher education, nonprofit, and private sectors.
- Propose state policies and actions that promote technology development and commercialization in Missouri.
- Study and make recommendations on issues that relate to improving the competitive position of Missouri in areas of science, R&D, and advanced technology development.
- Develop and implement a strategy to grow Missouri’s technology-driven economy.
- Oversee the implementation of this Missouri’s Life Science Strategy.
- Monitor trends and advancements in Missouri’s high technology industry sectors.
- Identify and encourage advanced and emerging technology industries to locate in Missouri.
- Oversee the state’s technology-based economic development programs.

It is proposed that the Science Advisor be appointed as the CEO for the Missouri Technology Corporation, which should be given responsibility for implementing the actions in this strategy. The responsibilities of MTC should be expanded and funding should be provided to enable the Governor’s Science and Technology Advisor to use the MTC as an implementation arm and to hire staff to implement the actions proposed in this strategy. It is estimated that \$1 million annually will be required to support the operations of MTC and the Governor’s Science and Technology Advisor. The Science and Technology Advisor’s budget would be approximately 30 to 40 percent of this total. Given that MTC is a private nonprofit, some of this funding could come from the private and philanthropic sector, in addition to the funding provided by the legislature.

Missouri has the basis for a strong delivery system to implement this strategy, including

- Four Innovation Centers, which if properly staffed with enhanced responsibilities can serve as primary regional coordinators and connectors

- MOBIO, which has emerged as a strong statewide advocate for the bio and life sciences with strong membership growth
- Strong regional organizations in the state’s two largest metropolitan areas, including the St. Louis Regional Chamber and Growth Association and the St. Louis Plant and Life Sciences Coalition in St. Louis and KC Catalyst and the Kansas City Area Life Sciences Institute Association in Kansas City, both with adopted life science strategies being actively implemented
- Emergence of interested regional groups and organizations in other rural and smaller metropolitan regions of the state, each with an important role to play in building “One Missouri.”

ACCOUNTABILITY AND MEASURES OF SUCCESS

It is recommended that the following measures be used to gauge success and progress in implementing Missouri’s life science strategy:

- Amount of, and increase in, life science R&D funding in the state
- Reputation and stature of the state’s research institutions in the life sciences as measured by citation analysis, funding, and reputation rankings
- Growth in the state’s life science economic base: number of firms, their employment, their concentration in the state relative to the nation, and birth and death rates of firms
- Level of, and increase in, life science venture capital invested in Missouri companies
- Funds leveraged to implement this strategy (all sources)
- Progress in implementation of the actions (monitor and chart progress).

In addition, this strategy should be reviewed and updated every three to five years as markets change and progress is made.

RESOURCES REQUIRED

The total annual cost of implementing the proposed strategies and actions is estimated to be between \$144 million and \$158 million. One-time costs, which would be spread over a five-year period, total \$125 million. It is proposed that these funds be drawn from a combination of sources, including dedicated tobacco settlement funds, revenue generated by cigarette taxes, direct appropriation by the legislature, bonding, and tax credits. It is estimated, using very conservative leverage ratios, that these dollars would leverage approximately \$2.1 billion in federal, private sector, and philanthropic funding. It is critical that the state focus its limited resources in funding initiatives in the life sciences, particularly now that funding from the tobacco settlement fund was reappropriated and the Health Life Science ballot initiative failed.

Of the \$144 million to \$158 million in annual costs, it is proposed that \$50 million for the Missouri Life Science Opportunity Fund could be raised by a bond issue if the state is unable to provide a direct appropriation. It is proposed that the remainder, approximately \$94 million (\$108 million at the upper range), be provided by a combination of direct appropriations, tax credits, and reallocation of existing resources. In addition to these costs, it is anticipated that

\$150 million would be provided by means of state pension fund investments in a Missouri Fund of Funds.

Table 9 provides estimated funding requirements for all the actions identified in this strategy.

Table 9: Financial Requirements for “One Missouri”

Action	Annual	One-Time	Source	Dollars Leveraged
Funding for legislatively approved capital projects of the UM System		\$41.75 million	Direct appropriation	
Missouri Life Science Opportunity Fund that will invest in research facilities, faculty/endowed chairs, and life science equipment	\$50 million annually for 10 years		Direct appropriation or bond issue	\$1.5 billion in federal and private R&D research funding over 10 years
R&D Partnership Program	\$3 million		Direct appropriation	\$9 million in private company matching funds
Incentive funding to educational and research institutions that form joint consortia with industry	\$300,000		Direct appropriation	
Innovation Centers and satellite operations	\$1 million, FY 2002 \$2 million, FY 2003 \$3 million, FY 2004 \$4 million, FY 2005		Direct appropriation	\$10 million during FY 2002–2005 from local sources
Life science wet-lab incubators and accelerators		\$14 million over 4 years	Direct appropriation	\$24 million over 4 years from local sources, primarily pre-seed, angel, private/philanthropic
Technology Development Funds		\$ 9 million	Direct appropriation	
Expanded technology transfer functions	\$350,000 per institution		Internal resources of universities and research institutions	
Missouri-based Fund of Funds		\$150 million (not an appropriation)	State pension funds	\$450 million in private investments
Strategic Facility Investment Fund		\$60 million	Direct appropriation of tax credits	\$60 million by private sector

Table 9: Financial Requirements for “One Missouri” (continued)

Action	Annual	One-Time	Source	Dollars Leveraged
Tax changes	\$10 million		Reduction in state tax revenues	
Life Science Special Project Fund	\$40 million		Direct appropriation	\$40 million by private investors
Marketing and business development initiative	\$5 million		Direct appropriation	
Incentives to higher education institutions to work with industry to develop life science curricula and workforce development programs	\$250,000 to \$750,000		Direct appropriation	
Internship/Co-op Program	\$500,000		Direct appropriation	
Workforce survey	\$250,000		Direct appropriation	
Governor’s Science Advisor and expanded Missouri Technology Corporation	\$1 million		Direct appropriation and foundation support	

ECONOMIC IMPACT ANALYSIS¹⁶

The strategies and actions outlined in the preceding sections were analyzed using the Policy Insight dynamic economic impact model created by Regional Economic Models, Inc. (REMI) to estimate the likely economic impacts of the directed investments made by the state government of Missouri. The REMI model was calibrated specifically for the Missouri regional economy, encompassing five geographic regions and 53 industry sectors and covering the years from 2003 to 2012.

The strategies and actions were modeled through the consideration of three basic types of economic impacts:

- Direct effects—Government spending to fund construction or provide matching research grants, reduced capital costs to businesses resulting from tax credits, employment generated in creating a state-level technology authority.
- Indirect effects—Increased academic research activity, new start-up firms, and relocation of existing firms to Missouri due to the strategies and actions, along with the employment generated therein.

¹⁶ The economic impact analysis was conducted in May 2002 and was not updated for the final release of the strategy in January 2003.

- Costs incurred—Each action funded by the Missouri state government necessitates an equivalent decrease in state funding.¹⁷

In most cases, direct effects were modeled through increases in output to particular economic sectors, rather than increases in demand or in employment, to avoid the model’s assumption of out-of-state “leakage” in satisfying increased demand and to retain monetary terms. Assuming that the actions are funded by general state revenues (except for the two actions funded from the tobacco settlement and from state pension funds), the costs incurred are allocated by population. The effect of assuming that funding for the actions results in reductions in total state expenditures is to increase the state’s impact on the life science portion of the economy. Given the sector’s heavy focus on R&D and high proportion of well-paid jobs, spending on the life sciences results in a greater economic stimulus than alternative uses of state funds.

To consider indirect effects, a detailed outcome model was constructed (separately from the REMI impact model) to predict the actions’ effects upon firm formation, industrial relocation, and the growth of sponsored academic research and its implications. The internal assumptions and ratios are based upon Battelle’s extensive work in other regions of the country, as well as region-specific information collected through other stages of Battelle’s engagement in Missouri, and are applied in a manner appropriate to Missouri’s current economic development situation.

If the action items are acted upon as envisioned, the net economic impact in year 10 will be (Figure 23): 22,110 jobs created; \$1.351 billion in Gross Regional Product; and \$703 million in real disposable personal income.

In total, through year 10 (2012), the Missouri region will have gained nearly \$7.2 billion in Gross Regional Product and more than \$3.9 billion in real disposable personal income. These figures are additional to the baseline economic forecasts—i.e., they represent the change that will occur in the economy if the actions are taken as opposed to if they are not taken. Depending upon the continuation of these actions and programs past year 10, annual gains should continue beyond year 10 as well; although this model cannot provide such forecasts.

Figure 24 depicts the additional employment created, and Figures 25 through 27 illustrate the distribution of the economic impacts across the three Missouri regions and the out-of-state areas included in the analysis. As might be expected, whereas relatively few jobs and Gross Regional Product dollars migrate to the Kansas and Illinois portions of the Kansas City and St. Louis metropolitan areas, a significant fraction of the disposable personal income generated does accrue to out-of-state residents of the two metropolitan regions.¹⁸ Fluctuations in the impact measures reflect the annual level of expenditures as well as adjustments in the model for changing resource constraints, labor migration rates, and economies of scale.

It is important to note that a large portion of the economic impacts are due to the increase in academic research conducted in Missouri’s public research universities. Without the envisioned success in attracting outside research funding from the federal government as well as private

¹⁷ It would also have been possible to model these costs as being funded through increases in state taxes. For the purposes of this analysis, however, it was simpler and perhaps more realistic to model the costs as resulting in decreased state spending, obviating the need for allocating increased revenue to specific taxes and jurisdictions.

¹⁸ The model does not reveal how many jobs, how much value of production, or how much personal income flows out of the study region entirely to neighboring states, the remainder of the United States, and the rest of the world.

Figure 23: Year 10 (2012) Differences from Baseline Forecast

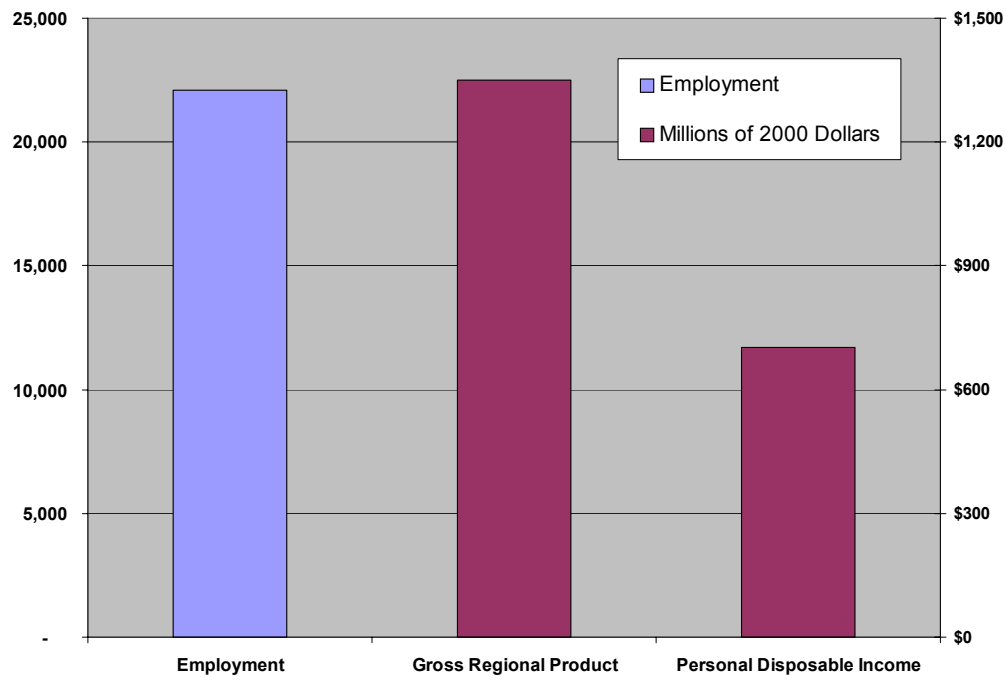


Figure 24: Total Employment by Scenario—Missouri Region

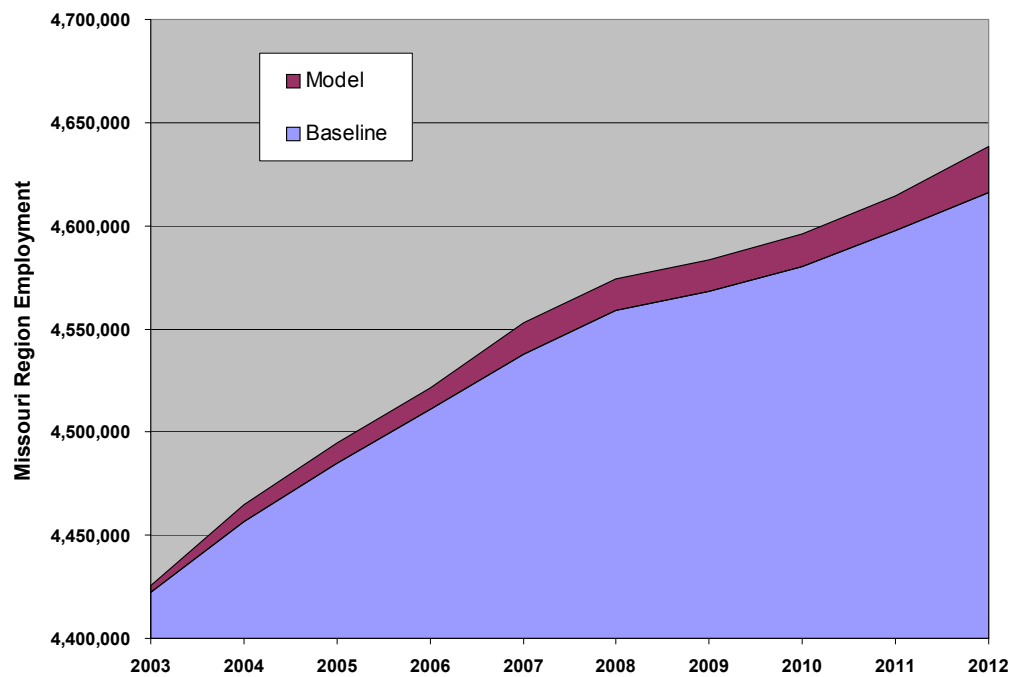


Figure 25: Jobs Created by Actions—Metropolitan Regions

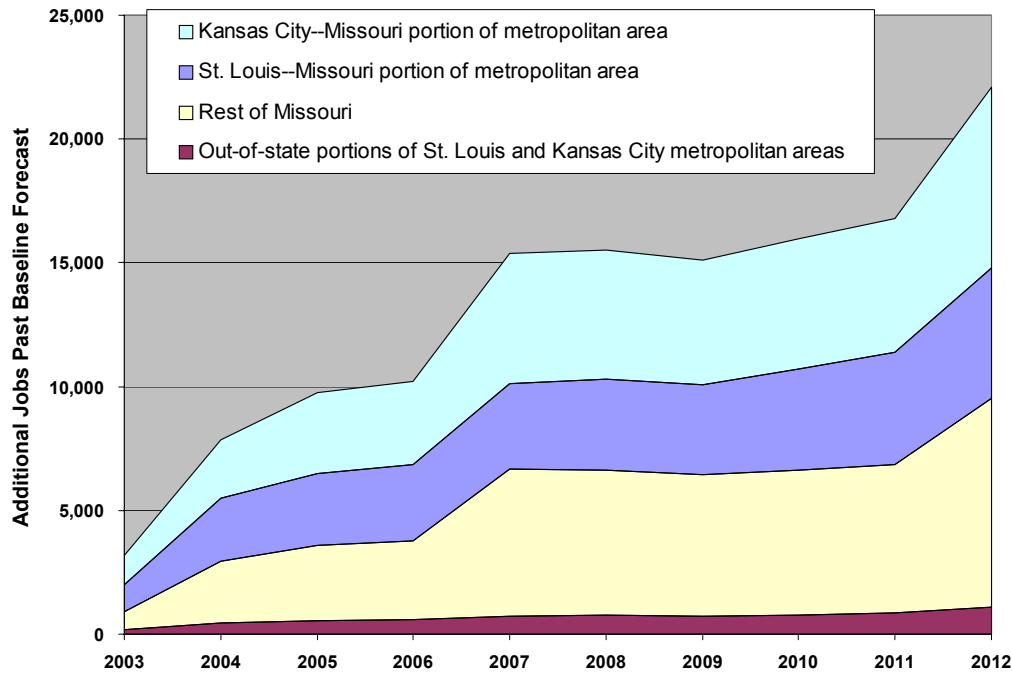


Figure 26: Regional Product Created by Actions—Metropolitan Regions

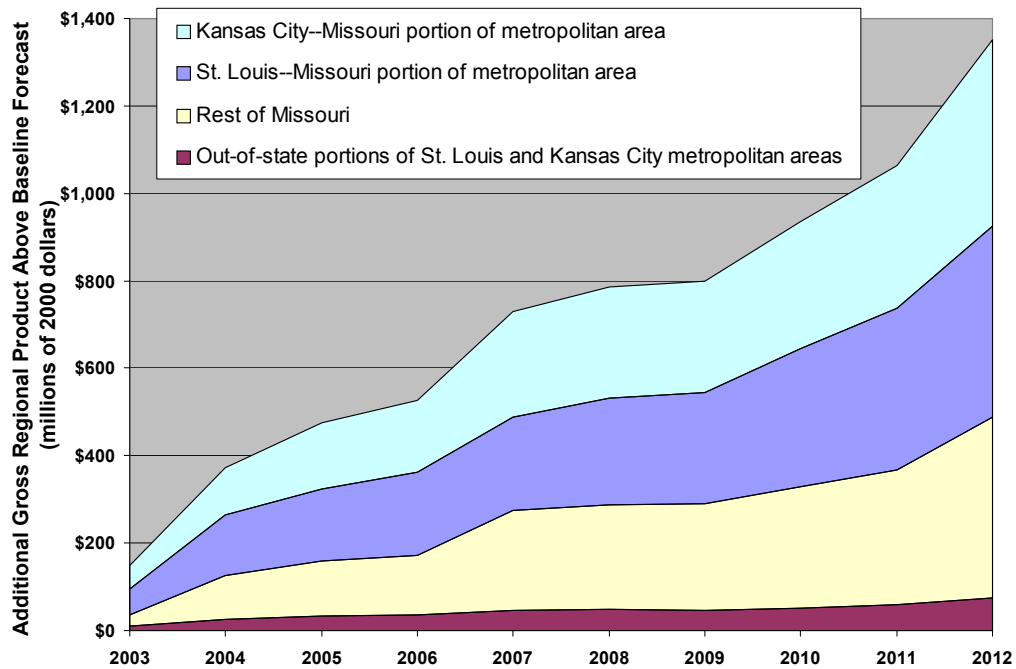
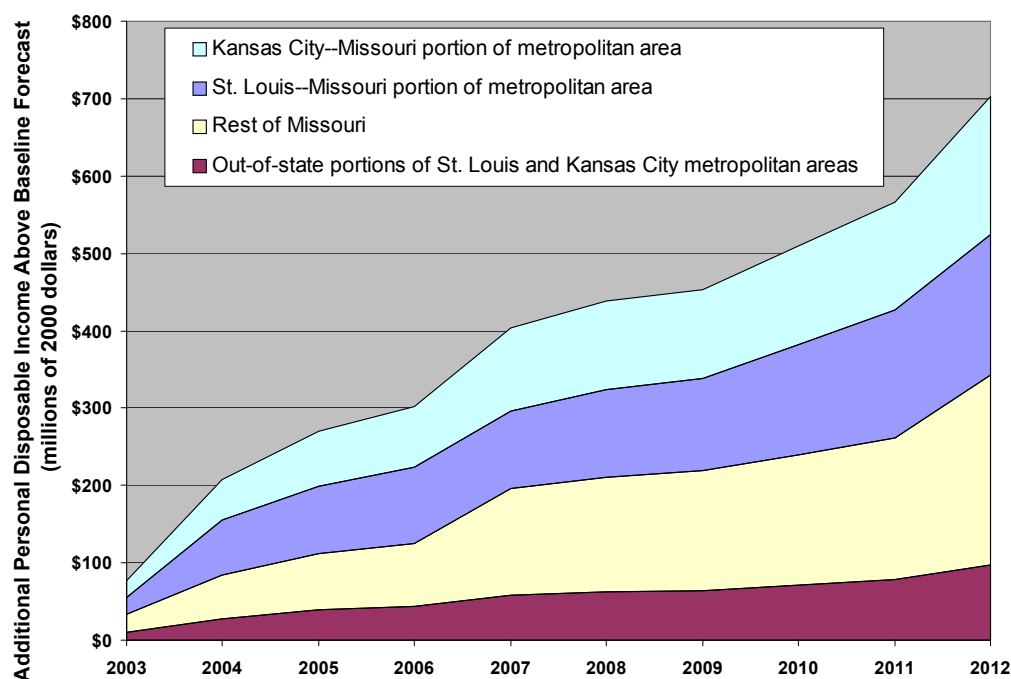


Figure 27: Disposable Personal Income Created by Actions—Metropolitan Regions



sources, enabled and leveraged by facilities construction and matching research grants, the impressive economic returns presented in this analysis would not be attainable. Yet all of the actions are influential in ensuring that the academic research yields economic benefits in the form of commercialized technologies and processes, viable business ventures, and lasting economic benefit to the State of Missouri.

PROJECTED EMPLOYMENT IMPACTS

Projected employment growth is another aspect of the impacts that enacting the proposed strategies and actions will have on the Missouri economy. The projected changes in employment discussed in this section are based on extrapolations, i.e., they estimate employment growth by assuming that industry subsectors will continue to grow (or decline) for the next 10 years at the same rate of growth as they did in 1995–2001. Please note that the economic impact estimates presented in the previous section were calculated using the REMI model, which includes its own assumptions regarding industry growth.

According to the information collected from the Dun & Bradstreet *MarketPlace* survey and presented in the “Economic Impact Analysis” section, the Missouri region’s life science sector grew by 11.0 percent in terms of employment between 1995 and 2001. Whereas the hospital and laboratory subsector dominates by virtue of its predominant size, both it and the research and testing subsector expanded rapidly in terms of employment over the roughly six-year time period, gaining 17.5 and 27.4 percent in employment, respectively. If these rates of employment growth were to continue through 2012, the period considered in the strategies and actions and in the impact analysis, the hospital and laboratory subsector would soar to nearly 208,000

employees, and the research and testing subsector would surpass 9,500 employees, more than 60 percent greater than its 2001 employment level.

Because the stark declines in drugs and pharmaceuticals employment have been due mostly to consolidation of existing firms, they are unlikely to continue in a fashion similar to the last six years. Yet, if the rate of decline proceeded apace, the drug and pharmaceutical subsector would shrink to just under 5,400 employees by the end of 2012, nearly a 50 percent decline from the 2001 employment level. Medical devices and instruments, which also declined in employment due to consolidations and mergers as well as some out-migration of firms, would drop 14 percent of its employment, down to about 6,900 workers in 2012.

The food and nutrition and organic and agricultural chemicals subsectors, relatively stable in employment, would change little at the current rates of growth, together gaining less than 300 employees from 2001 through 2012.

Overall, the life science sector would grow 22.6 percent in terms of employment, with more than 87 percent of the employment gains in the hospital and laboratory subsector (Table 10 and Figures 28 and 29).

Table 10: Missouri Region—Life Science Subsectors

Subsector	Measured Employment (Dun & Bradstreet)			Extrapolation of Current Trends	
	1995 Q4	2001 Q3	% Change 1995-2001	2012 Q4	% Change 2001-2012
Food and Nutrition	9,307	9,346	0.4	9,423	0.8
Organic and Agricultural Chemicals	7,798	7,896	1.3	8,091	2.5
Drugs and Pharmaceuticals	14,651	10,443	-28.7	5,384	-48.4
Medical Devices and Instruments	8,674	8,032	-7.4	6,910	-14.0
Research and Testing	4,645	5,918	27.4	9,506	60.6
Hospitals and Laboratories	128,945	151,482	17.5	207,602	37.0
TOTAL	174,020	193,117	11.0	236,754	22.6

The entire Missouri state economy (not including the portions of the Kansas City and St. Louis metropolitan areas located in Kansas and Illinois) gained some 159,000 jobs between 1996 and 2000, according to ES-202 data collected by the Missouri Department of Development. In the major economic sectors, the greatest percentage gains in employment, more than 10 percent over the four-year period, were witnessed by construction; agriculture; fire, insurance, and real estate; services; and transportation and public utilities (Table 11).

Figure 28: Missouri Region Life Science Extrapolation—with Hospitals

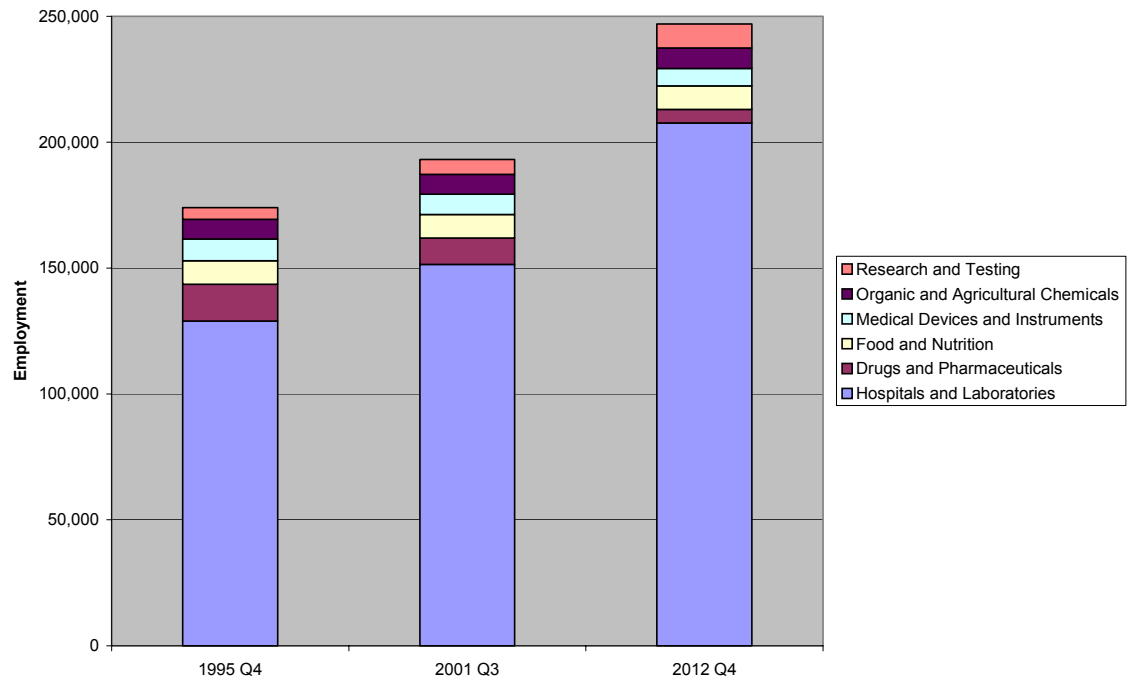


Figure 29: Missouri Region Life Science Extrapolation—without Hospitals

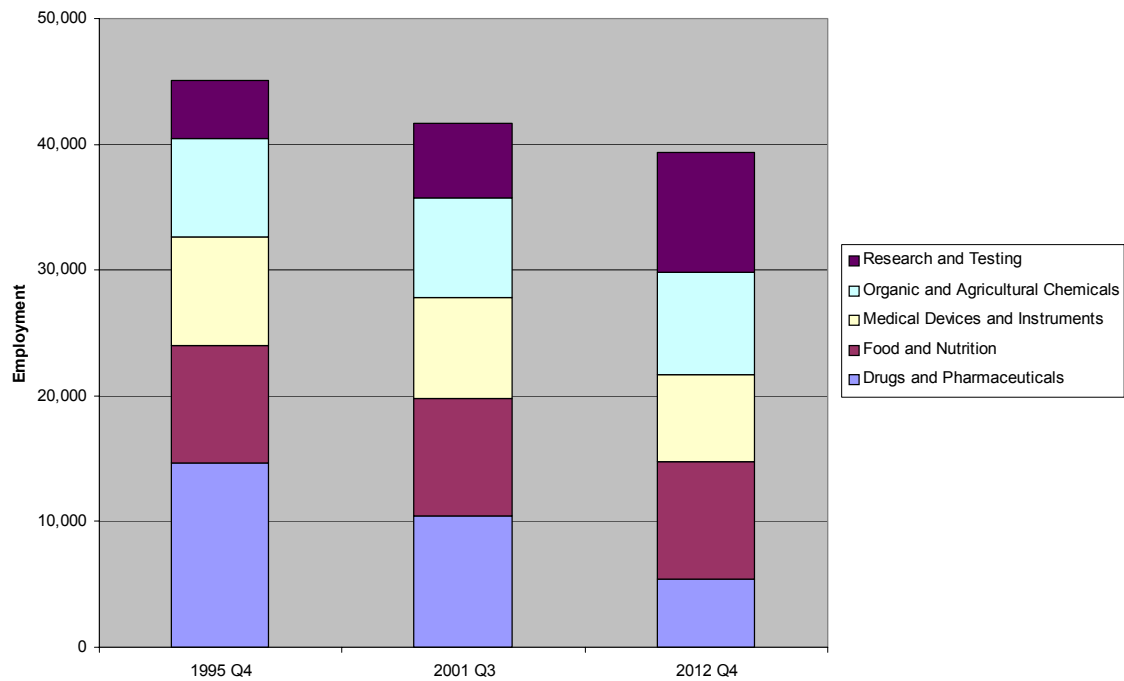


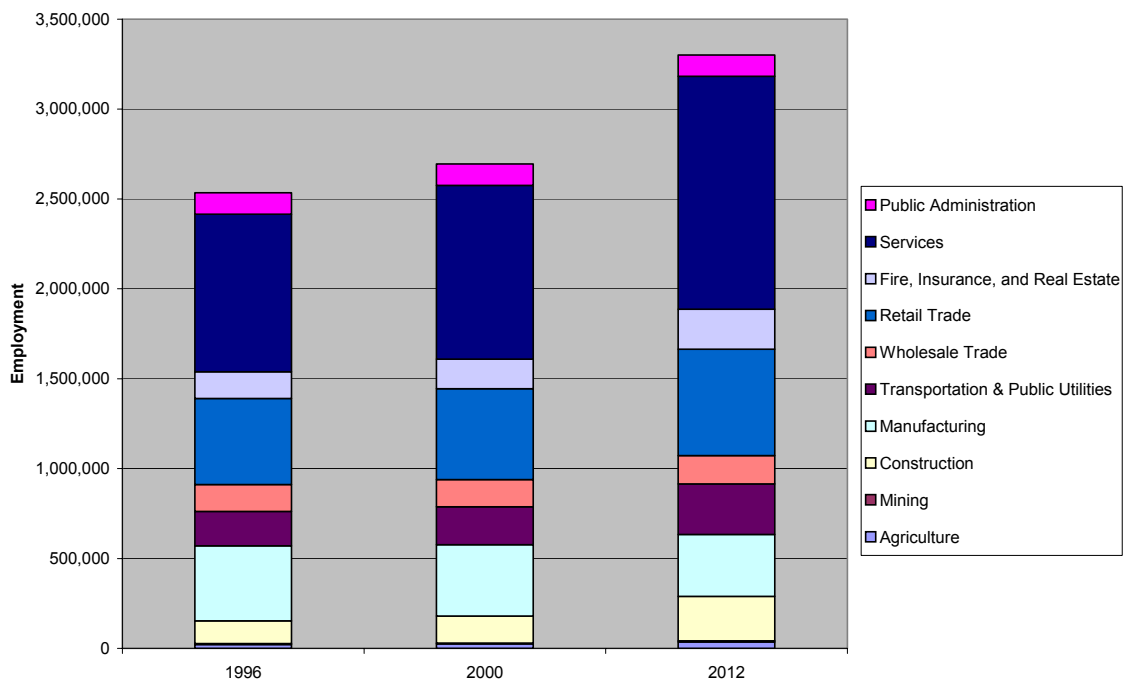
Table 11: State of Missouri—Entire Economy

Economic Sector	Measured Employment (ES-202)			Extrapolation of Current Trends		With Policy Impacts (REMI)	
	1996	2000	% Change 1996-2000	2012	% Change 2000-2012	2012	% Above Extrap
Agriculture	21,800	24,642	13.0	35,591	44.4	35,645	0.15
Mining	4,857	5,080	4.6	5,812	14.4	5,823	0.19
Construction	126,856	149,959	18.2	247,718	65.2	248,325	0.25
Manufacturing	416,760	397,221	-4.7	343,931	-13.4	345,825	0.55
Transportation and Public Utilities	191,859	211,176	10.1	281,599	33.3	281,910	0.11
Wholesale Trade	149,016	151,196	1.5	157,929	4.5	158,360	0.27
Retail Trade	479,307	505,194	5.4	591,550	17.1	593,598	0.35
Fire, Insurance, and Real Estate	148,335	164,174	10.7	222,580	35.6	223,326	0.34
Services	876,455	966,579	10.3	1,296,464	34.1	1,315,273	1.45
Public Administration	119,486	118,893	-0.5	117,132	-1.5	113,241	-3.32
TOTAL	2,534,731	2,694,114	6.3	3,300,306	22.5	3,321,326	0.64

The only sectors to decline were public administration (very slightly) and manufacturing (by nearly 5 percent, or close to 20,000 jobs). If manufacturing were to continue to decline at the current pace, more than 50,000 additional jobs would be lost to the state by the end of 2012 in this relatively high-paying sector. Meanwhile, the economy as a whole would add more than 600,000 jobs within the state, a gain of more than 22 percent, with almost half of them within the burgeoning but relatively low-paying and low-benefit services sector.

If the strategies and actions proposed by Battelle were enacted as suggested, more than 21,000 permanent jobs would be added to the Missouri state economy by the end of 2012, according to impact analysis and projections calculated using a model from REMI. Although the lion’s share would be in the services sector (18,800 jobs), a large proportion would be in the life science and biomedical services. The rest of the employment impacts would be spread throughout the other sectors of the Missouri economy, with nearly 2,000 additional manufacturing jobs being the highlight. The only sector to decline in employment as a result of instituting the strategies and actions suggested would be public administration, assuming that the funds for many of the action items would come from reducing current state government spending rather than from increasing taxes or other revenue sources (Table 11 and Figure 30).

Figure 30: State of Missouri Extrapolation



Conclusion

The State of Missouri is fortunate to possess strong assets in the life sciences that offer tremendous potential for the state’s economy. The various metropolitan regions already have developed and begun implementing life science strategies that the State of Missouri can build upon and leverage in its own statewide strategy. However, to accelerate the regional agendas and establish Missouri as the Midwest’s leading center for the life sciences, the state must act aggressively.

However, recent state actions and proposals suggest no full understanding of the costs of not moving forward and making key investments in the life sciences beginning now—not two years or five years from now. Battelle projects that ***if this strategy is implemented promptly, Missouri will add more than 21,000 permanent, mostly high-paying jobs in the life science industries. During the 10 years from 2003 until 2012, the Missouri region will have gained nearly \$7.2 billion in Gross Regional Product and more than \$3.9 billion in real disposable personal income.*** Depending upon the continuation of these actions and programs past year 10, annual gains should continue beyond year 10 as well; although this model cannot provide such forecasts. Failure to act may mean that Missouri will be left behind in the race to develop a vibrant, high-paying life science sector.

Missouri must make critical investments in the future to become a leader in tomorrow’s life science economy. Life sciences represent a clear path for building “One Missouri”—one that benefits rural and urban areas alike; takes full advantage of current state investments in higher education to maximize their return in terms of wealth and jobs; and builds on a traditional bioprocessing base around newer life science breakthroughs to help establish, expand, and attract the industries of the future for Missouri.

Missouri is at a crossroads. The state can lead or be left behind. The actions proposed in this strategy, if implemented, will propel Missouri forward in a race that Missouri cannot afford to lose.